LIS2-A Host-PC communication Selectra, Flexor, Pro and EL Series

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1 Introduction

1.1 Purpose

This document defines the interface between a Laboratory Information System (LIS) and an analyser. The analyser can be a XL, E, Junior, Pro-and EL series analyser. The LIS is in this document referred to as 'Host'.

1.2 Scope

The scope of this document is limited to defining the external interface of the PC at the analyser side.

1.3 Definitions, acronyms and abbreviations

Abbreviation	Description
Host	Computer that is part of the LIS and communicates with the analyser PC.
LIS	Laboratory Information System

Definition	Description
Request buffer	The list of samples and tests that have been ordered at the analyser. The samples are not yet loaded onto the analyser. A request can be modified.
Result buffer	The list of samples and tests that are measured or currently being measured.

1.4 References

[1]   CLSI. *Standard Specification for Low-Level Protocol to Transfer Messages Between Clinical Laboratory Instruments and Computer Systems.* CLSI document LIS1-A [ISBN 1-56238-489-9]. CLSI, 940 West Valley Road, Suite 1400, Wayne, Pennsylvania 19087-1898 USA, 2003.

[2]   CLSI. *Standard Specification for Transferring Information Between Clinical Instruments and Computer Systems.* CLSI document LIS2-A [ISBN 1-56238-490-2]. CLSI, 940 West Valley Road, Suite 1400, Wayne, Pennsylvania 19087-1898 USA, 2003.)

1.5 Overview

Chapter 2 defines the low-level interface between PC and Host.
Chapter 3 defines the format of the low-level frames transmitted between PC and Host.
Chapter 4 defines the general format of the high-level messages transmitted between PC and Host.
Chapter 5 defines the format of the individual messages that can be transmitted between PC and Host.

2 Hardware interfaces

2.1 Serial port interface

The characteristics for the physical layer of the communication are defined in CLSI standard LIS1-A (See [1]), Section 5 *Physical Layer for Serial Binary Data Exchange.*

The line signal definition is shown in the following table:

DB-25 pin #	DB-9 pin #		Signal name	Direction	Remarks
7	5	SG	Signal Ground		
2	3	TD	Transmit data	output	data from analyser-PC to host
3	2	RD	Receive data	input	data from host to analyser-PC
4	7	RTS	Request To Send	output	*
5	8	CTS	Clear To Send	input	*
20	4	DTR	Data Terminal Ready	output	*
6	6	DSR	Data Set Ready	input	*
8	1	CD	Carrier Detect	input	not used
22	9	RI	Ring Indicator	input	not used

- The only pins really used are TX and RX, the usage of the rest (marked *) depends on the settings of the COM-port of the analyser-PC.

- The default setting for communication will be 9600 baud, 8 databits, no parity, 1 stopbit (8-N-1).

Warning:
The XON-XOFF protocol (which can be set by Windows) must NOT be used, because this can interfere with the protocol.

2.2 Network interface

The characteristics for the physical layer of the communication are defined in CLSI standard LIS1-A (See [1]), Section 7 *Physical Layer for TCP/IP Data Interchange*

Configuration of TCP/IP network adapter on the analyser is outside the scope of this document, refer to the analyser manual.

For host communication the analyser allows setting host IP address and port number to define the host socket. The analyser will connect to host socket after reset or as soon as communication is enabled in system settings.

The connection will remain active as long as the PC application is running on the analyser. If for some reason the TCP/IP connection is lost (e.g., because host system was restarted), then the analyser will continuously try to reconnect.

3 Data handling

3.1 General

The properties for the message sending and receiving are defined in CLSI standard LIS1-A (See [1]), Section 6 *Data Link Layer.* The analyser software implements the standard and this section is only intended to provide a short summary. For detailed information on error handling, time-out behavior and contention, please refer to the standard.

The LIS1-A standard defines a line-bidding protocol that will define the receiver and sender for communication. A system ready to send information will transmit an <ENQ> character. The receiver will reply with <ACK> if it is ready to receive or <NAK> when it is busy. Refer to the state diagram in Annex A1 of the standard [1].

After sender and receiver have been determined, the sender will transmit frames. Each frame starts with an <STX> character and ends with <ETB> or <ETX> character, a checksum and <CR> <LF>. The content of a frame is the message that is to be sent (see chapter 4).

The receiver will acknowledge the frame with <ACK> or <EOT>, or it may indicate an error by responding with <NAK>. The <EOT> character indicates that the receiver has information to send and requests that the line is returned to idle state. The sender may honor the <EOT> by responding with <EOT> or it may ignore the <EOT> and send the next frame.

After the sender has transmitted an <EOT> character, the line is returned into idle state.

3.2 Frame format

The format of frames is:

For intermediate frames:

<STX>	FN	*text*	<ETB>	C1	C2	<CR>	<LF>

For end frame:

<STX>	FN	*text*	<ETX>	C1	C2	<CR>	<LF>

<STX>	=	Start of Text transmission control character (ASCII 2)
FN	=	Single Digit Frame number ASCII '0' to '7', starting with '1'
text	=	Body of message, refer to following chapters
<ETB>	=	End of Transmission Block transmission control character (ASCII 23)
<ETX>	=	End of Text transmission control character (ASCII 3)
C1	=	Most significant character of checksum 0 to 9 and A to F
C2	=	Least significant character of checksum 0 to 9 and A to F
<CR>	=	Carriage Return ASCII character (ASCII 13)
<LF>	=	Line Feed ASCII character (ASCII 10)

The total size of a frame shall not exceed 64,000 bytes. Messages longer than 64,000 bytes are split into multiple frames. A frame can contain only a single message.
The Frame number must start with the ASCII character '1' for the first frame that is transmitted after the <ENQ> character.

4 Messages

4.1 General

This section describes the format of messages between the analyser and the host. These messages are formatted according to the LIS2-A standard (See [2]).

Messages are can be sent spontaneously or as a response to a query for information.

Each message consists of one or more records, each record is terminated with a carriage return character (ASCII 13). The following example shows the flow of control of a message from a sender to a receiver. The characters below ASCII 32 are written in the notation: $^S_{T_X}$ (ASCII 2). The complete ASCII code chart is provided in Appendix C, for more examples, refer to Appendix D.

Sender: $^E_{N_Q}$
Receiver: $^A_{C_K}$
Sender: $^S_{T_X}$1H|\^&||||SELE||||1.0|||P|LIS2-A|20060126163201^C_RQ|1|^12936-
            A||ALL|||||||||O^C_RL|1|F$^C_R$$^E_{T_X}23^C_R$$^L_F$
Receiver: $^A_{C_K}$
Sender:$^E_{O_T}$

A host may transmit more fields and records than are specified in this document. The analyser shall ignore those fields and records.

If the analyser receives a message that does not contain the required fields, it will ignore the message.

The analyser does not verify the correct sequential numbering of records from the host. However, the record sequence number and record type fields are required fields by standard LIS2-A and are included in the message. (In contrast, the frame number as defined in Chapter 3 (LIS1-A) must be sequentially numbered and is checked by the analyser. Incorrect frame numbering will lead to rejection of the frame.)

4.2 Record format

The message format texts follow standard LIS2-A (see [2]).

All records are formatted with delimiters. For the host protocol, the following delimiters are used:

> Field delimiter: Vertical bar (|) Latin-1 (124)
> Repeat delimiter: Backslash (\) Latin-1 (96)
> Component delimiter: Caret (^) Latin-1 (94)
> Escape delimiter: ampersand (&) Latin-1 (38)

The following escape sequences are recognized and transmitted by the analyser:

> &F&   imbedded Field delimiter character
> &S&   imbedded Component delimiter character
> &R&   imbedded repeat field delimiter character
> &E&   imbedded escape delimiter character

In cases where fields are limited to a maximum (e.g., sample_ID, patient name), this maximum applies to the number of characters without replacing imbedded field delimiters by their escape sequence. Example: Sample ID "15\a" is transmitted as "15&R&a"; but the number of characters for maximum limit is 4.

Except for the record-ID, the text fields are case-sensitive. This means that the analyser performs all text comparisons sensitive the the case of the text field. For instance a request containing a character 's' in the priority field, will not be interpreted as 'S' (STAT) and a test request 'Asat' will not match with a test called 'ASAT' on the analyser.

5 Messages to host

This section describes the messages that are sent from the analyser to the host. For host implementation, the minimally required fields are marked 'yes', unmarked fields are optional. The numbering of the fields is indentical to the numbering used in the CLSI LIS2A standard [2].

5.1 Header (H)

Every message contains a header record. The header record contains the following fields:

Field		Analyser (Transmitted to host)	Host		Comment
			Received from host	Required	
7.1.1	Record Type ID	**H**	**H**	yes	
7.1.2	Delimiter Definition	**|\^&**	**|\^&**	yes	Other field delimiters are not supported.
7.1.3	Message Control ID	*<empty>*	*<ignored>*		
7.1.4	Access Password	*<empty>*	*<ignored>*		
7.1.5	Sender Name or ID	device_id^ software_version	*<ignored>* or host_id		device_id: text defined in communication parameters of analyser application. software_version: text containing current software version of sending application. host_id: text identifying the host (see note below)
7.1.6	Sender Street Address	*<empty>*	*<ignored>*		
7.1.7	Reserved Field	*<empty>*	*<ignored>*		
7.1.8	Sender Telephone Number	*<empty>*	*<ignored>*		
7.1.9	Characteristics of Sender	**1.7**	*<ignored>*		Version number of host protocol.
7.1.10	Receiver ID	host_id	*<ignored>* or device_id		host_id: text identifying the host (see note below)
7.1.11	Comment or Special Instructions	*<empty>*	*<ignored>*		
7.1.12	Processing ID	**P**	*<ignored>*		
7.1.13	Version No.	**LIS2-A**	*<ignored>*		
7.1.14	Date and Time of Message	current date/time	*<ignored>*		YYYYMMDDHHMMSS

Device ID
The field device_id is used to identify the analyser and can be used as extra security that the tests are performed on the correct analyser. It can be up to 20 characters long.

7.1.5 Sender Name or ID
If a host_id is defined in the analyser application, and a host_id is present in the received message, then the message will be ignored if the host_id in the received message is not equal to the host_id in the analyser application. A field may contain more components, these will be ignored. Note that if the host_id in the message or the host_id in the analyser application is empty, this rule does not apply.

7.1.10 Received ID
if a device_id is defined in the analyser application, and a device_id is present in the received message, then the message will be ignored if the device_id in the received message is not equal to the device_id in the analyser application. A field may contain more components, these will be ignored. Note that if the device_id in the message or the device_id in the analyser application is empty, this rule does not apply.

Example header from analyser:

```
H|\^&|||SELXL^2.1.0||||1.0|HOST||P|LIS2-A|20060120153902
```

```
H|\^&|||SELXL^2.1.0||||1.0|HOST||P|LIS2-A|20060120153902
```

5.2 Patient information record (P)

The patient record contains the patient information. Every request from the host starts with a patient record, followed by one or more order records (see section 5.3). Results from the analyser start with a patient record, followed by one or more order records, where each order record is followed by one or more result records (see section 5.4). Full examples are provided in Appendix D Examples.

Field		Analyser (Transmitted to host)	Host		Comment
			Received from host	Required	
8.1.1	Record Type ID	**P**	**P**	yes	
8.1.2	Sequence Number	number	*<ignored>*	yes	Sequential number starting with **1** and continuing until the last patient in the message
8.1.3	Practice Assigned Patient ID	<empty>	*<ignored>*		
8.1.4	Laboratory Assigned Patient ID	<empty>	*<ignored>*		
8.1.5	Patient ID No. 3	<empty>	*<ignored>*		
8.1.6	Patient Name	sample_name	sample_name		maximum 20 characters
8.1.7	Mother's Maiden Name	<empty>	*<ignored>*		
8.1.8	Birthdate	date_of_birth	date_of_birth		YYYYMMDD
8.1.9	Patient Sex	M F U	<empty> M F U		The contents of this field define the applicable reference limits: **M**: male **F**: female **U**: pediatric Default: **M**

8.1.9 Patient Sex
On the instrument, the operator may rename 'male', 'female' and 'pediatric', this does not have an effect on the characters used in the host protocol. These are fixed to **M**, **F** and **U** respectively.

Example patient information record from analyser:
```
P|1||||Henry Johnson||19650714|M
```

5.3 Test order record (O)

The order record contains information on the test to be performed for the preceding patient record (see 5.2).

Field		Analyser (Transmitted to host)	Host		Comment
			Received from host	Required	
9.4.1	Record Type ID	O	O	yes	
9.4.2	Sequence Number	number	*<ignored>*	yes	Sequential number starting with **1** and continuing until the last order for the patient
9.4.3	Specimen ID	<empty> sample ID	<empty> sample ID	yes	Maximum 12 characters Empty for calibrator, control and blanks.
9.4.4	Instrument Specimen ID	<empty> Calibr. name Control name `BLANK`	<empty> Calibr. name Control name `BLANK`		For analyser 'samples' like calibrators, controls, and blank measurements, the specimen ID field (9.4.3) will be empty to avoid conflicts. This field identifies calibrator by name; control by name or blank. **See notes below**
9.4.5	Universal Test ID	<empty>	^^^abbr_test	yes	Abbreviated test name max 4 characters long. Host may send multiple requests in single order record by use of repeat delimiter. **See notes below**
9.4.6	Priority	`S` `A` `R`	<empty> `S` `A` `R`		**S** (Stat) **A** (ASAP / Pediatric) **R** (Normal) All other will be treated as **R**. Default: **R**
9.4.7	Requested/Ordered Date and Time	<empty>	*<ignored>*		
9.4.8	Specimen Collection Date and Time	<empty>	*<ignored>*		
9.4.9	Collection End Time	<empty>	*<ignored>*		
9.4.10	Collection Volume	<empty>	*<ignored>*		
9.4.11	Collector ID	<empty>	*<ignored>*		
9.4.12	Action Code	<empty>	<empty> `N` `A` `C`		Empty and other will be treated as **N** **See notes below**
9.4.13	Danger Code	<empty>	*<ignored>*		
9.4.14	Relevant Clinical Information	<empty>	*<ignored>*		
9.4.15	Date/Time Specimen Received	<empty>	*<ignored>*		
9.4.16	Specimen Descriptor	sample type `BLANK` `CALIBRATOR` `CONTROL`	<empty> sample type		**See notes below**
9.4.17	Ordering Physician	Name	<empty> name		Max 20 characters. In case this field contains multiple components, only the first component is used.
9.4.18	Physician's Telephone Number	<empty>	*<ignored>*		
9.4.19	User Field No. 1	<empty>	*<ignored>*		
9.4.20	User Field No. 2	<empty>	*<ignored>*		
9.4.21	Laboratory Field No. 1	<empty>	*<ignored>*		

9.4.22	Laboratory Field No. 2	<empty>	*<ignored>*		
9.4.23	Date/Time Results Reported or Last Modified	<empty>	*<ignored>*		
9.4.24	Instrument Charge to Computer System	<empty>	*<ignored>*		
9.4.25	Instrument Section ID	<empty>	*<ignored>*		
9.4.26	Report Types	F X I	<empty> O Q Y Z		see notes below

9.4.4 Instrument Specimen ID
When a calibrator, control or blank is requested from the host, fields with sample information will be ignored.

9.4.5 Universal Test ID
To request ISE tests, the value for **abbr_test** must be **ISE**. The analyser reports ISE results as a single Order record and separate result records for each ISE result, containing '^^^ISE^K', '^^^ISE^Na', etc. in the result record.

Example ISE result from analyser:
```
O|1|12935-C|||R|||||||||||Dr. Carnegy||||||||||F C R
R|1|^^^ISE^K|4.2|mmol/l|||||F|||||20060120153902 C R
R|2|^^^ISE^Na|139|mmol/l|||||F|||||20060120153902 C R
R|3|^^^ISE^Cl|111|mmol/l|||||F|||||20060120153902 C R
```

9.4.12 Action code
N New request: If a request with the same Sample ID already exists, that request will overwritten. If the sample is in process or ready, and still loaded, a new request is made and the name, birthdate, etc. must be equal to the sample that is in process.

A Additional requests: The contents of the order record will be appended to an existing sample request on the analyser. This means that the set of test requests is extended with the test requests in the order record. If a request does not exist or was already started a new request is created.

C Cancel: will remove the entire sample request from the request buffer. The contents of field (9.4.5) will be ignored if **C** is specified.

If an action code is not provided the order will be treated as a *New Request*.

9.4.16 Specimen Descriptor
This (optional) field contains in full text the sample type. For instance if the sample is urine, this field contains **Urine**. The text is compared case sensitive to the sample types defined on the insturment. If the sample type is not known or not defined, it will default to **Normal**.

When transmitted by the analyser, this field can contain any of the defined sample types or the fixed texts **BLANK, CALIBRATOR** or **CONTROL**.

Example Order record with sample type:
```
O|1|12935-C|||R|||||||||||Urine|Dr. Carnegy||||||||||F C R
```

9.1.26 Report Type (transmitted by analyser):
F Final: Indicates a result is following and that it is the last result for the sample.

I Intermediate: Indicates a result is following and that the sample still has active measurements.

X Used to indicate a request to measure is not accepted by the analyser. The request may be rejected for the following reasons:
- Sample_ID already exists, but demographic information doesn't match, i.e., Patient name and birth date are not equal to an existing request.

- No space for request, i.e., the request buffer is full.
No results will be transmitted for the request.

9.1.26 Report Type (received by analyser):
The field will be ignored if action code (field 12) is C.

O, Q, <empty>	The requests will replace an existing sample request.
Y, Z	A Host can use these values in response to a host query to indicate that a Sample ID is not known at the host. Depending on implementation, a message may be shown on the screen of the analyser. See also Section 5.6, Field 13.1.3.
<others>	The record will be ignored.

Limitations:

The sample ID in the order record is used to identify the sample request on the analyser, cancelling the order means that the sample request – including patient information – is deleted from the analyser.

If the analyser is active when the request is received and the sample is already loaded on the analyser, the requested test is automatically started. This behaviour is intended for reflex tests transmitted from host.

If a request (identified with a sample ID) has a name, birth date or other demographic information that conflicts with a request on the analyser, the request will be rejected by the analyser.

Example order record from analyser:
`O|1|12934-A||^^^CHOL|R|||||||||||Dr. Carnegy|||||||||F`^C_R

5.4 Result record (R)

For every order record the analyser will report 1 or more result records.

Field		Analyser (Transmitted to host)	Host (Received from host)	Comment
10.1.1	Record Type ID	`R`		
10.1.2	Sequence Number	number		Sequential number starting with 1 and continuing until the last result for the patient.
10.1.3	Universal Test ID	^^^abbr_test^full_test		Abbreviated test name up to 4 characters long; Full test name up to 15 characters long. **See notes below**
10.1.4	Data or Measurement Value	result		**See notes below**
10.1.5	Units	units		See Appendix B
10.1.6	Reference Ranges	cutoff_reference^ low_reference_limit^ high_reference_limit		All components are floating point values. cutoff_reference contains the relevant reference value for positive/negative reporting. low_reference_limit and high_reference_limit define the applicable reference range (male/female/pediatric) for the sample. **See notes below**
10.1.7	Result Abnormal Flags	normalcy_flags^ instrument_flags	This record is always ignored when received from host	normalcy flags: `L` : Below low reference limit `LL`: Below low panic limit `H` : Above high reference limit `HH`: Above high panic limit `<` : Below absolute limit `>` : Above absolute limit Instrument flags: See Appendix A for an overview of possible values
10.1.8	Nature of Abnormality Testing	<empty>		
10.1.9	Result Status	`F` `I` `X`		`F` indicates a final result `I` indicates a result is pending (Field 10.1.4 will contain BUSY or ------) `X` indicates the order cannot be done, it will be transmitted immediately upon request to perform tests that are not known at the analyser, the result will show **UNKNOWN**.
10.1.10	Date of Change	<empty>		
10.1.11	Operator Identification	<empty>		
10.1.12	Date/Time Test Started	<empty>		
10.1.13	Date/Time Test Completed	meas_datetime		YYYYMMDDHHMMSS
10.1.14	Instrument Identification	analyser_section^ reagent_batch_nr^ reagent_expiry_date		analyser _section: (XL-series only:) `L`: Left analyser part `R`: Right analyser part reagent_batch_nr and reagent_expiry_date contains the batch number and expiry date of the first reagent of the test.

10.1.3 Universal Test ID

For ISE results, the field is formatted as follows:

    ^^^ISE^K
    ^^^ISE^Na
    ^^^ISE^Cl
    ^^^ISE^CO2

Refer to section 5.3 field 9.4.5 for an example.

10.1.4 Data or Measurement value

The field can contain the following:

Floating point number	The measured value in human readable format, the decimal separator is a period (.)
`REJECT`	The test was rejected (either automatically by the analyser, or manually by the operator)
`BUSY`	The test is being measured at the analyser.
`------`	The test is waiting for operator input. On screen displayed as *INFO*.
`> n.nnnn`	Measurement above assay range. Where *n.nnn* is a floating point value representing the highest concentration level defined in the test parameters.
`< n.nnnn`	Measurement below analytical sensitivity. Where *n.nnnn* is a floating point value representing the lowest concentration level defined in the test parameters.
`UNKNOWN`	The test request was unknown at the analyser. Results records reporting **UNKNOWN** to the host will not show in the result list of the analyser.

10.1.6 Reference ranges

When a control result is reported to the host, the reference ranges are replaced with control limits as follows:

    Control target^Confrol low limit^Control high limit

For blank and calibrator results, this field will be empty.

10.1.7 Result abnormal flags

The component *normalcy_flags* will specify '<' or '>' if the value is outside a range other than a reference range. The component *instrument_flags* will provide more detail of the range that was exceeded. The following table lists the instrument flags and the normalcy flags that will be set accordingly:

Instrument flags		Normalcy flag
`n`	Reference low error	`L`
`y`	Reference panic low error	`LL`
`N`	Reference high error	`H`
`Y`	Reference panic high error	`HH`
`<`	Absorbance low limit error	`<`
`U`	Measurement counter underrange	
`u`	Reference counter underrange	
`v`	Measurement below low calibration limit	
`x`	Measurement below analytical sensitivity	
`>`	Absorbance high limit violation	`>`
`o`	Measurement counter overrange	
`o`	Reference counter overrange	
`V`	Measurement above high calibration limit	
`X`	Measurement above assay range	

General

By default the analyser sends the results to the host as soon as they become available. This means that the analyser will send multiple result messages for a single sample (1 for each test result). It also means that if there is a tests that requires operator attention (the test has an *INFO*), then this test will not hold back sending of results. The field *Report Type* (9.1.26) is used to indicate if the sample has still has active tests that are being measured, or if it is the last test for the sample.

Alternatively, the option *Collate Results* may be set in the analyser, in which case the analyser will not send the test results for a sample, until all tests for that sample are completed. It will then send all results in a single message.

In case the test measurement is performed with a repeat value > 1 (The test must have been requested at the analyser console, since the host request does not support specifying a repeat value), each individual measurement is reported to the host. The host can identify these results as different measurement by inspecting the value of the measurement date/time field (Field 10.1.13).

Example result record from analyser:
```
R|1|^^^C300^+Cocaine 300|0.276|dAbs/m|0.301|^-
||F||||20060120153902|L^Z2820^20060701^C_R
```

5.5 Comment record (C)

The format of the comment record depends on the context in which it is received or transmitted.

Comments for Test order record (O)

Following a test order record there can be a comment record containing a specific comment for the sample.

Field		Analyser (Transmitted to host)	Host (Received from host)	Comment
11.1.1	Record Type ID	C	C	
11.1.2	Sequence Number	1	*<ignored>*	Sequential number starting with 1 and continuing until the last comment on this level.
11.1.3	Comment Source	I	*<ignored>*	
11.1.4	Comment Text	text	Text	See below
11.1.5	Comment Type	**G**	*<ignored>*	

If the instrument receives a comment record following the test order record, the text from the comment record will be placed in the sample comment record. If multiple comment records are received, only the last comment record will be copied into the sample comment record, thereby overwriting any previously received comments.

The instrument will store only the first 100 characters of the received comment text.

Comments for Result records (R)

If 'extended results' is enabled in communication settings, the instrument will add comment records following the result record. These comment records contain raw result information for the transmitted result.

Field		Analyser (Transmitted to host)	Host (Received from host)	Comment
11.1.1	Record Type ID	`C`	The comment record following the result record is always ignored when received from host	
11.1.2	Sequence Number	`1`		Sequential number starting with 1 and continuing until the last comment on this level.
11.1.3	Comment Source	`I`		
11.1.4	Comment Text	code^text		See below
11.1.5	Comment Type	**G**		

> `C|`*<sequence number>*`|I|M01^`*<abs_result>*`^`*<abs_units>*`|G`
>
> <abs_result>   Calculated absorbance value based on raw measurements.
> <abs_units>   Relevant absorbance units (Abs, dAbs, dAbs/m)
>
> `C|`*<sequence number>*`|I|M02^`*<seconds>*`^`*<raw_result>*`^`*<used>*`|G`
>
> seconds   Time at which measurement was performed. This is a floating point value.
> raw_result   floating point value specifying the raw absorbance measurement by the analyser
> used   0 or 1: 1 indicates the point is used by the analyser to calculate the concentration; 0 indicates the measurement was not used.
> The field *Comment Text* is repeated for every raw measurement point.

In case a 'test repeat' is set in the test parameters, the raw measurements are sent for each repeat. With a test repeat of 3, this means that 6 comment records will be appended for each result.

Raw results from the ISE are reported in the format as they are received from the ISE unit. Currently the ISE units reports only final results. Only an M01 field will be transmitted.

Example:
```
C|1|I|M01^0.276^dAbs/m|G
C|2|I|M02^24.5^0.2313^0\M02^51^0.2320^0\M02^77.5^0.7123^0\[additional values skipped for brevity]|G
```

5.6 Message Terminator Record (L)

Every message must be terminated with a Message Terminator record. Since every frame can only contain 1 message, this also terminates the frame (See 3.2).

Field		Analyser (Transmitted to host)	Host Received from host	Required	Comment
13.1.1	Record Type ID	`L`	`L`	yes	
13.1.2	Sequence Number	`1`	*<ignored>*	yes	Always 1
13.1.3	Termination Code	`F`	`Q` `I`		

When Termination Code (13.1.3) received from host is `Q` or `I` then this is taken to mean that the host has no information on the sample ID in the last request. Depending on implementation, a message may be shown on screen.

5.7 Request information record (Q)

Field		Analyser (Transmitted to host)	Host		Comment
			Received from host	Required	
12.1.1	Record Type ID	Q	Q	yes	
12.1.2	Sequence Number	1	*<ignored>*	yes	Sequential number starting with 1 and continuing until the last request for this message
12.1.3	Starting Range ID Number	^sample_ID	^sample_ID or **ALL**	yes	In case ALL is received by the analyser; the analyser will (re)send the last 100 results in the result buffer.
12.1.4	Ending Range ID Number	<empty>	*<ignored>*		Only a single sample ID can be requested in each query record.
12.1.5	Universal Test ID	**ALL**	*<ignored>*		By default **ALL** results for a sample are transmitted.
12.1.6	Nature of Request Time Limits	<empty>	*<ignored>*		
12.1.7	Beginning Request Results Date and Time	<empty>	*<ignored>*		
12.1.8	Ending Request Results Date and Time	<empty>	*<ignored>*		
12.1.9	Requesting Physician Name	<empty>	*<ignored>*		
12.1.10	Requesting Physician Telephone Number	<empty>	*<ignored>*		
12.1.11	User Field No. 1	<empty>	*<ignored>*		
12.1.12	User Field No. 2	<empty>	*<ignored>*		
12.1.13	Request Information Status Codes	O	*<ignored>*		

Whenever the analyser encounters a new sample ID for which it can not find a request in the request buffer, it sends a 'request information record' to the host system, requesting to send test orders and demographics. The analyser will never cancel an outstanding request.

When the analyser receives a request it will always respond by sending all results for the requested sample ID as they are at that time. These results may be Final (F) or in analyser pending (I).

5.8 Manufacturer Information Record (M)

This record is used for custom information exchange not covered in the CLSI protocol LIS2A. These include:
- Sending cuvette blank information to the host
- Requesting full version information of all analyser parts
- Downloading error history information from analyser
- Reagent installation information and statistics

These information records are always level 1 records

Field		Analyser (Transmitted to host)	Host (Received from host)	Comment
15.1.1	Record Type ID	`M`	`M`	
15.1.2	Sequence Number	`1`	*<ignored>*	Only 1 manufacturer information record is allowed for each message.

5.8.1 Cuvette Blank information (B)

The cuvette blank information is sent by the analyser when the operator presses Ctrl+F1 in the Blank Rotor menu. The blank results of the selected filter (and for XL-series: analyser half) are sent to the host.

If the host requests blank information by sending an `M|1|B`, then all blank information, for all cuvettes and all wavelengths is transmitted to the host.

Field		Analyser (Transmitted to host)	Host (Received from host)	Comment
3	Manufacturer Record Type ID	`B`	`B`	
4	Analyser part	<empty> `L` `R`	*<ignored>*	E / Junior: <empty> XL-Series: **L**eft or **R**ight analyser part.
5	Wavelength	<wavelength>	*<ignored>*	Wavelength in nanometers.
6	Cuvette blank value	<value>	*<ignored>*	Absorbance value for each cuvette, the value is repeated 48 times.
7	Cuvette average	<value>	*<ignored>*	
8	Cuvette Standard Deviation	<value>	*<ignored>*	
9	Lamp average	<value>	*<ignored>*	
10	Lamp Standard Deviation	<value>	*<ignored>*	

Example message with cuvette blank information

```
H|\^&|||SELXL^2.1.0|||||1.0|||P|LIS2-A|20051221153902ᶜ_R
M|1|B|L|340|0.1029\0.1030\0.1041\0.1032<44 values skipped for brevity>|0.1033
    |0.0012|0.0291|0.0009ᶜ_R
L|1|Fᶜ_R
```

5.8.2 Error History

Note: this record is primarily intended for use by Vital Scientific BV during production and service of the analyser and is subject to change.

The error history is only transmitted to the host after the host has requested the error history. The host performs an error history request by sending an `M|1|H` record.

The following fields are appended to the Manufacturer Information Record:

Field		Analyser (Transmitted to host)	Host (Received from host)	Comment
3	Manufacturer Record Type ID	H	H	
4	Error History record	error_datetime^ error_message^ operator_action	*<ignored>*	Field is repeated for each item in error history
5	Action code	<empty>	<empty> C	C: Clear error history

Component	Content	Length	Comment
error_datetime	YYYYMMDDHHMMSS	14	date and time of error
error_message	text	5	Error code (e.g., E102)
operator_action	digit	1	A code identifying the action of the operator: 0 – None 1 – Check Again 2 – Acknowledge 3 – Reset System 4 – Specific Reset 5 – Remain Inactive 6 – Halt 7 – Analyser side reset

Example message with error history:
```
H|\^&|||SELXL^2.1.0|||||1.0|||P|LIS2-A|20051221153902CR
M|1|H|20050827151007^E12^0\20050827151210^E17^0\20051009101247^E13^6CR
L|1|F CR
```

5.8.3 Reagent installation (I)

Reagent Installation information is sent automatically from the analyser to the host whenever the reagent configuration on the analyser changes. Alternatively the host can request reagent installation information by sending a `M|1|I` record.

The following fields are appended to the Manufacturer Information Record:

Field		Analyser (Transmitted to host)	Host (Received from host)	Comment
3	Manufacturer Record Type ID	`I`	`I`	
4	Reagent installation information	position^ abbr_test^ full_test^ reagent_nr^ reagent_batch^ reagent_expiry^ test_count	*<ignored>*	Field is repeated for each installed reagent

Component	Content	Max Length	Comment
position	text	3	Text/Number identifying reagent position: For Junior: 1..30 For E: 1..32 For XL-Series: L1..L32, R1..R32
abbr_test	text	4	Abbreviated test name
full_test	text	15	Full test name
reagent_nr	number	1	1..3 for reagent 1..3
reagent_batch	text	10	reagent batch number
reagent_expiry	YYYYMMDD	8	Reagent Expiry date
test_count	number		Total test count for installed reagent

The location of reagents used for normal operation of the analyser (e.g., HCL and NEEDLE RINSE) and shared reagents (e.g., SHARED BUFFER) are not reported to the host.
Reagents are reported ordered by position of the reagents on the rotor.

Example:
The following message indicates 2 tests are installed on the analyser; "+Cocaine 150" and "LSD".
Reagent 1 for "+Cocaine 150" is on position 1; Reagent 3 on position 2. For LSD reagent 1 is located on rotor position 5 and reagent 3 is located on position 6. "+Cocaine 150" has executed a total of 290 tests; while "LSD" has been used for 165 tests.

```
H|\^&|||JUNIOR^2.1.0|||||1.0|||P|LIS2-A|20060120162301 C R
M|1|I|1^+C15^+Cocaine 150^1^^^290\2^+C15^+Cocaine 150^3^^^290\
      5^LSD^LSD^1^^^165\6^LSD^LSD^3^^^165 C R
L|1|F C R
```

5.8.4 Extended version information

Note: this record is primarily intended to be used by Vital Scientific BV during production and service of the analyser and is subject to change.

The extended version information is only transmitted to the host after the host has performed a request by sending an `M|1|V` record.

Extended version information can be used to request version information for all parts used in the analyser.

Field		Analyser (Transmitted to host)	Host (Received from host)	Comment
3	Manufacturer Record Type ID	v	v	
4	Version information	part^ version	*<ignored>*	Field is repeated for each analyser part

Component	Content	Length	Comment
part	number	2	Unique number identifying the analyser part: 1 PC release description 2 PC release version 3 PC application version 4 PC application date 5 CCB version (XL-series only) 6 Sample Disc Version 7 Barcode version (XL-series only) 8 (Left) Master version 9 (Left) Master Date 10 (Left) Pipettor version 11 (Left) Measurement unit version 12 (Left) Sample arm version 13 (Left) Reagent arm version (XL and E-series only) 14 (Left) Reagent discs version (XL and E-series only) 15 (Left) Wash arm version 16 Right master version (XL-series only) 17 Right master date (XL-series only) 18 Right Pipettor version (XL-series only) 19 Right Meas. Unit version (XL-series only) 20 Right Sample arm version (XL-series only) 21 Right Reagent arm version (XL-series only) 22 Right Reagent disc version (XL-series only) 23 Right wash arm version (XL-series only)
version	text		Text describing version or date as it was received from the analyser.

Example response with version information:

```
H|\^&|||XL400^4.0.0|||||1.7|Host||P|LIS2-A|20080103120702  C R
M|1|V|1^XL Analyser 4.0\2^4.0.0\3^4.0.0\4^20071225\5^XL/VTLV1.3.1\
6^DSC P0.03    \7^\8^XL/DRY V1.1.0(DUAL)\9^14-APR-2004  13:49\
10^DIL V1.10    \11^MDS V1.10    \12^SA  V1.10    \13^RA  V1.20    \
14^DSC V1.10    \15^WA  V1.11    \16^XL/DRY V1.1.0(DUAL)\
17^14-APR-2004  13:49\18^DIL V1.10    \19^MDS V1.10    \
20^SA  V1.10    \21^RA  V1.20    \22^DSC V1.10    \23^WA  V1.11 C R
L|1|F C R
```

Appendix A Flags

When there are irregularities during the measurement of a test, the analyser will flag the result with a single character describing the nature of the irregularity. There may be multiple flags added to a result. The flags may appear in random order.

The analyser will transmit these flags to the host in the result record field 10.1.7.2 as described in section 5.4.

Flag	Error description
*	Alinearity error
#	Insufficient sample
A	Calibrator point absorbance violation
a	Reagent absorbance limit violation
B	Barcode not matching (XL-series only)
b	Barcode not scanned (XL-series only)
C	Control limit violation
D	Reagent absorbance deviation error/substrate depletion error
E	Cut-off result near limit
F	Test not performed because of disabled analyser part
G	General hardware error
H	Calculated result division by zero
h	Calculated result condition not satisfied
I	General ISE unit error
K	Measurement above high calibration limit
k	Measurement below low calibration limit
L	Lamp error if combined with O, o, U, u flag; otherwise ISE electrode not calibrated
M	Absorbance high limit violation
m	Absorbance low limit error
N+	High reference limit violation
N−	Low reference limit violation
O	Measurement counter overrange
o	Reference counter overrange
P	Prozone error
R	Insufficient reagent
r	Rerun
T	Cuvette temperature error
U	Measurement counter underrange
u	Reference counter underrange
V	Cutoff positive
v	Cutoff negative
W	Westgard violation
X	Measurement above assay range
x	Measurement below analytical sensitivity
Y	Reference panic high error
y	Reference panic low error
Z	Dup-diff error

Appendix B Units

The next table shows all the possible units.

<empty>	mEq/l	ng/ml	mg/24h
kU/l	g/l	IU/l	µg/24h
U/l	mg/l	IU/ml	sec
U/ml	µg/l	mIU/l	units
µU/ml	ng/l	mIU/ml	Abs
µkat/l	g/dl	µIU/ml	ratio
mol/l	mg/dl	%	dAbs
mmol/l	µg/dl	‰	dAbs/m
µmol/l	ng/dl	% norm	
nmol/l	mg/ml	m/24hr	
fmol/g	µg/ml	g/24hr	

Table 1: Available units in analyser

Character codes used for the special characters ‰ (Per mille sign; Latin-1 137) and µ (micro sign; Latin-1 181) depend on the codepage that is currently active in the PC application on the analyser. The transmitted code may differ based on the language that is used for the user interface.

Appendix C ASCII CODE Chart

000	NUL	016	DLE	032	SP	048	0	064	@	080	P	096	`	112	p
001	SOH	017	DC1	033	!	049	1	065	A	081	Q	097	a	113	q
002	STX	018	DC2	034	"	050	2	066	B	082	R	098	b	114	r
003	ETX	019	DC3	035	#	051	3	067	C	083	S	099	c	115	s
004	EOT	020	DC4	036	$	052	4	068	D	084	T	100	d	116	t
005	ENQ	021	NAK	037	%	053	5	069	E	085	U	101	e	117	u
006	ACK	022	SYN	038	&	054	6	070	F	086	V	102	f	118	v
007	BEL	023	ETB	039	‘	055	7	071	G	087	W	103	g	119	w
008	BS	024	CAN	040	(	056	8	072	H	088	X	104	h	120	x
009	HT	025	EM	041	)	057	9	073	I	089	Y	105	i	121	y
010	LF	026	SUB	042	*	058	:	074	J	090	Z	106	j	122	z
011	VT	027	ESC	043	+	059	;	075	K	091	[	107	k	123	{
012	FF	028	FS	044	,	060	<	076	L	092	\	108	l	124	|
013	CR	029	GS	045	–	061	=	077	M	093	]	109	m	125	}
014	SO	030	RS	046	.	062	>	078	N	094	^	110	n	126	~
015	SI	031	US	047	/	063	?	079	O	095	_	111	o	127	DEL

Table 2: 7-bit ASCII code chart

Appendix D Examples

The following shows the flow of control of a message from a sender to a received. In this case the sender is the analyser performing a query request at the host (See example 4)

Sender: $^E_{N_Q}$

Receiver: $^A_{C_K}$

Sender: $^S_{T_X}$1H|\^&||||SELE||||1.0|||P|LIS2-A|20060126163201^C_RQ|1|^12936-A||ALL||||||||||O^C_RL|1|F$^C_R$$^E_{T_X}23^C_R$$^L_F$

Receiver: $^A_{C_K}$

Sender: $^E_{O_T}$

For readability the encapsulation of messages has been removed from the following examples.

D.1 Analyser messages

Example 1.1 Standard result from analyser
The following example shows results send by the analyser based on the host request from example 2.1.
When the first result is ready (GLUC), the analyser sends the following message to the host:
```
H|\^&|||SELE||||1.0|||P|LIS2-A|20060126162409^C_R
P|1|||||Lindsey Blake||19650917|F^C_R
O|1|12934-A|||R|||||||||||Dr. Carnegy||||||||||I^C_R
R|1|^^^GLUC^Glucose|8.1|mmol/l|^4.0^6.9|H^N||F||||20060126162405^C_R
L|1|F^C_R
```

For the second result (+C15), the analyser sends the following message to the host:
```
H|\^&|||SELE||||1.0|||P|LIS2-A|20060126162503^C_R
P|1|||||Lindsey Blake||19650917|F^C_R
O|1|12934-A|||R|||||||||||Dr. Carnegy||||||||||F^C_R
R|1|^^^+C15^+Cocaine 150|0.321|dAbs/m|0.231|^+||F||||20060126162459
     |^3T797^20070601^C_R
L|1|F^C_R
```

Example 1.2 Result from analyser as answer to host query
The same information as above can also be transmitted based on a query from the host or by pressing Ctrl+F1 in while the sample is selected on screen. All the results for a sample are then contained in a single message.

```
H|\^&|||SELJR||||1.0|||P|LIS2-A|20060126162409^C_R
P|1|||||Lindsey Blake||19650917|F^C_R
O|1|12934-A|||R|||||||||||Dr. Carnegy||||||||||F^C_R
R|1|^^^GLUC^Glucose|8.1|mmol/l|^4.0^6.9|H^N||F||||20060126162405^C_R
R|2|^^^+C15^+Cocaine 150|0.321|dAbs/m|0.231|^+||F||||20060126162459^C_R
      |^3T797^20070601^C_R
L|1|F^C_R
```

Example 1.3 Analyser query
This example shows a message that is sent by the analyser to query the host for information for a sample ID "12936-A".

```
H|\^&|||SELXL||||1.0|||P|LIS2-A|20060126163201^C_R
Q|1|^12936-A||ALL|||||||||O^C_R
L|1|F^C_R
```

Example 1.4 Analyser result message for calibration of Valproic Acid assay
```
H|\^&|||SELE||||1.0|||P|LIS2-A|20060127081927C R
P|1|||||||C R
O|1||VPA Calibrator||R|||||||||||||||||||||||F C R
R|1|^^^VPA^Valproic Acid|0.2258|dAbs/m||||F||||20060127081456C R
R|2|^^^VPA^Valproic Acid|0.2524|dAbs/m||||F||||20060127081550C R
R|3|^^^VPA^Valproic Acid|0.2837|dAbs/m||||F||||20060127081644C R
R|4|^^^VPA^Valproic Acid|0.3084|dAbs/m||||F||||20060127081738C R
R|5|^^^VPA^Valproic Acid|0.3631|dAbs/m||||F||||20060127081832C R
R|6|^^^VPA^Valproic Acid|0.3892|dAbs/m||||F||||20060127081926C R
L|1|F C R
```

Example 1.5 Analyser result message for ISE measurements
```
H|\^&|||SELE||||1.0|||P|LIS2-A|20060120153907C R
P|1|||||Jonathan Kardon||19650917|M C R
O|1|12939-C|||R|||||||||||||||||||||||F C R
R|1|^^^ISE^K|4.2|mmol/l||||F||||20060120153902C R
R|2|^^^ISE^Na|139|mmol/l||||F||||20060120153902C R
R|3|^^^ISE^Cl|111|mmol/l||||F||||20060120153902C R
L|1|F C R
```

D.2 Host messages

The following examples are provided to show how a host may communicate with the analyser. Fields that will be ignored by the analyser are mostly left empty in these examples, but these may contain actual data when sent from the host.

Example 2.1 Standard host request
The host requests a series of tests to be performed on a number of samples.
```
H|\^&|||LABLIS|||||||P|LIS2-A|20060126155702C R
P|1||||Lindsey Blake||19650917|F C R
O|1|12934-A||^^^GLUC\^^^+C15|R|||||||||||Dr. Carnegy||||||||||O C R
L|1 C R
```

Example 2.2 Minimal host request
This example presents a minimal host request for two tests (CREA & CHOL) to be performed on a sample with ID "123"
```
H|\^& C R
P|1 C R
O|1|123||^^^CREA\^^^CHOL C R
L|1 C R
```

Example 2.3 Complex host request
The following shows a complex request from the host. Various methods are used to specify the tests to be performed:

```
H|\^&|||LABLIS|||||||P|LIS2-A|20060126155702C R
P|1||||First SampleC R
O|1|12940||^^^GLUC\^^^CHOL|RC R
P|2||||Stat SampleC R
O|1|12941||^^^GLUC|SC R
O|2|12941||^^^CHOL|RC R
P|3||||ASAP SampleC R
O|1|12942||^^^GLUC|AC R
L|1|FC R
```

Note: The second sample request (Sample ID 12941), contains two order records: One test to be performed immediately (STAT), and one test to be performed as routine (normal). Since the priority in the analyser is set at sample level, the priority in the second test request will overwrite the priority in the first test request. All tests will be executed at normal priority, not STAT.

Example 2.4 Host response on analyser query
Upon an analyser query the host may respond in several ways. This example shows a complete response with some fields that will be ignored by the analyser, but the host may also respond with requests as shown in examples 1 and 3.

```
H|\^&|28319|PWD|HostSystem|||319 555-456||SELE||P|LIS2-A|20060126170103C R
P|1|12936|12936||John Dibbly||19710702|M||||MNYC R
O|1|12936-A||^^^CREA|R|20060126150557|||||N|||||Dr. Carnegy||||||||||QC R
L|1|FC R
```

Example 2.4 Host response on analyser query if sample ID is unknown
If the sample ID is not known at the host, the host may respond with the following message:
```
H|\^&C R
L|1|IC R
```

Or a more extensive reply:
```
H|\^&|28320||HostSystem|||||||||20060126170103C R
P|1C R
O|1|12936-A||||||||||||||||||||||||||||ZC R
L|1|FC R
```

A response from a host is not required, the query will time-out on the analyser after a few seconds.

Example 2.5 Sample request cancelled by host
Complete request is deleted:
```
H|\^&C R
P|1C R
O|1|12934-A|||||||||||CC R
L|1|FC R
```

Example 2.6 Host queries results from analyser:
```
H|\^&C R
Q|1|^12940-AC R
L|1C R
```

**** End of Document ***