LZR-FLATSCAN U

Communication protocol V1.0

Contents

1. Introduction

1.1 Scope

This document specifies the communication protocol at the RS485 output of the LZR®-FLATSCAN U.

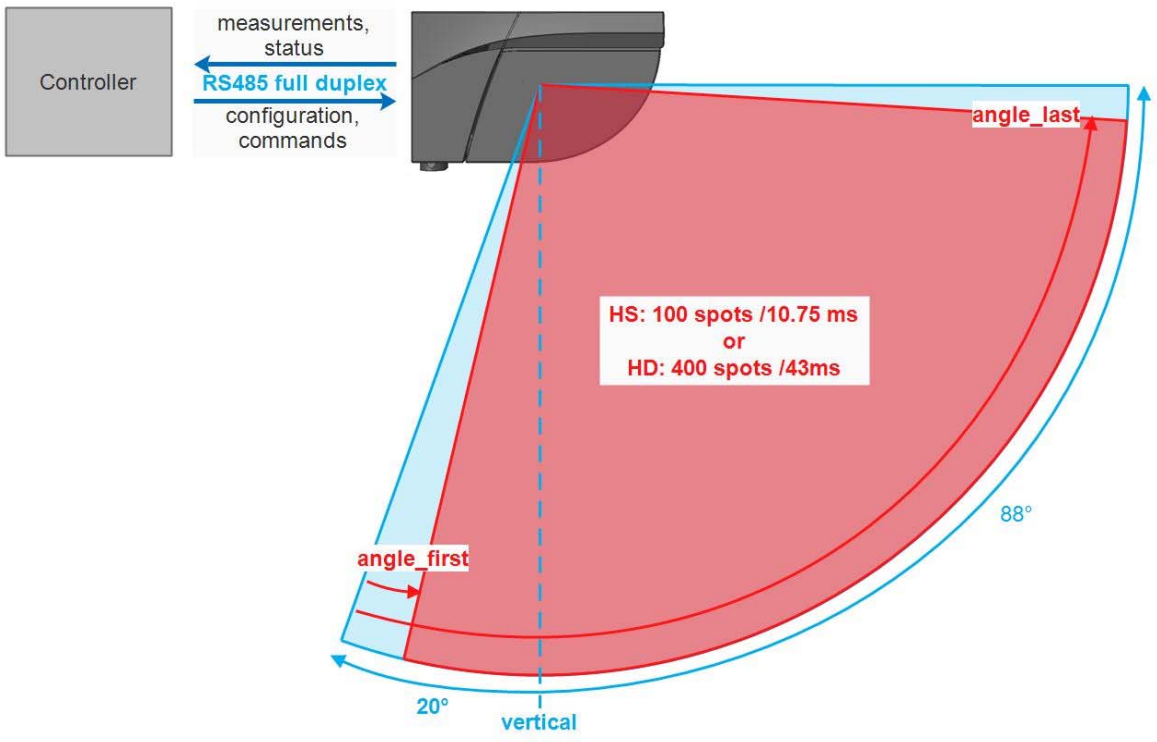
1.2 Definitions, acronyms and abbreviations

This subsection provides the definitions of all terms, acronyms, and abbreviations required to properly interpret this document.

- LZR®-FLATSCAN: Detection device.
- MDI: Measured distance information.
- HS zone: High speed zone (non-interlaced, available every 10.75ms).
- HD zone: High definition zone (interlaced, available every 43ms).

1.3 Presentation of the FLATSCAN raw data

The LZR®-FLATSCAN U is based on the FLATSCAN Platform. It is composed of a laser measurement head connected to a RS485 module.



The measurement head contains a rotating drum with 4 mirror facets that allows to scan an angle of 108° 4 times per rotation.
The detection field can be defined within the scan angle using the *angle first* and *angle last* parameters.
Two modes are available:

- **High speed mode (HS):** up to 100 spots in the detection field with a refresh period of 10.75ms (at the end of each facet).

- **High definition mode (HD):** up to 400 measurements in the detection field with a refresh period of 43ms (at the end of each drum rotation).

The RS485 module offers a bi-directional communication: it transfers distance and/or remission information to the controller in real time, and receives commands for driving the measurement head.

1.4 Rules for the definition of the detection field

The size of the detection field and the number of spots for HD and HS modes can be configured considering the following rules:

- The angles of the field are defined as follows: 0.00° ≤ angle_first < angle_last ≤ 108.00°
- In HS mode, the number of spots can be defined between 1 and 100.
- In HD mode, the number of spots can be defined between 4 and 400. It must be a multiple of 4.
- The spots are distributed evenly in the detection field. Minimum angle between spots is 0.74° for HS and 0.18° for HD. Depending on the angle of the zones, this condition can limit the number of spots.

	HS (high speed)	**HD (high density)**
Detection field	0 to 108°	
Refresh period	10.75ms	43ms
Number of spots	1 to 100	4 to 400 (multiple of 4)
Minimum separation between spots	0.74°	0.18°

2. Serial communication characteristics

The main characteristics of the communication are presented in the table:

Type	Asynchronous
Electrical interface	RS485
Communication mode	Bi-directional full-duplex
Baud rate	57600 to 921600 (configurable)
Topology	Point to point
Encoding	1 start bit, 1 stop bit, no parity bit
Data word length	8 bits
Byte order	Little-endian, LSB first

3. Communication protocol

3.1 General communication frame format

For all communication modes between controller and FLATSCAN, the communication frame is divided into 4 main fields: SYNC, CMD, message, CHK.
The byte order is little endian, LSB first.

General communication frame			
SYNC	CMD	data	CHK
11 bytes	2 bytes	0 to 1609 bytes	2 bytes

3.1.1 SYNC field

The SYNC field contains a synchronization pattern and information about the frame format and verification method.

<table>
<tr><td>Bytes 0 to 3</td><td>synchronisation pattern : 0xbea01234</td></tr>
<tr><td>Byte 4</td><td>version of the protocol: fixed to 0x02</td></tr>
<tr><td>Bytes 5, 6</td><td>total size of the frame in bytes (SYNC + CMD + data + CHK)</td></tr>
<tr><td>Byte 7</td><td>Verification method:
• bits 0 to 3: fixed to 2 for CRC16
• Bits 4 to 7: reserved for future use, read and write 0.
<table>
<tr><td>b7</td><td>b6</td><td>b5</td><td>b4</td><td>b3</td><td>b2</td><td>b1</td><td>b0</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td></tr>
</table></td></tr>
<tr><td>Bytes 8 to 10</td><td>Reserved for future use, read and write 0.</td></tr>
</table>

3.1.2 CMD field

The CMD field is defines the type of message. The value for CMD is defined for each in the next paragraphs for each message.

3.1.3 DATA field

The data field contains the information of the message. Its format and size depend on the type of message.
In messages that are sent spontaneously by the detector (measurements, heartbeat, emergency), the data contains optional CAN (serial number) and CNTR (frame counter) fields that allow checking integrity of the communication. In measurement messages, the data contains also optional CTN (temperature) and facet fields.

3.1.4 CHK field

The CHK contains the verification pattern of the frame, which is a CRC16.
All bytes of the SYNC, CMD, and DATA are considered for computing the CHK. Details about the CRC coding are given in a dedicated paragraph.
If the FLATSCAN receives a frame with incorrect verification code, the frame is ignored.

3.2 Messages from host to FLATSCAN

The messages that can be sent from host to FLATSCAN are summarized in the table below. An answer is associated to each of them.

Message from host to FLATSCAN			
Frame	**CMD**	**Length of data**	**answer**
SET_BAUDRATE	50001 (0xc351)	1 byte	Acknowledge: SET_ BAUDRATE (50001)
GET_MEASUREMENTS	50011 (0xc35b)	1 byte	MDI (50011)
GET_IDENTITY	50010 (0xc35a)	0	SEND_IDENTITY (50010)
GET_EMERGENCY	50030 (0xc36e)	0	EMERGENCY (50030)
GET_PARAMETERS	50004 (0xc354)	0	SEND_PARAMETERS (50004)
SET_PARAMETERS	50003 (0xc353)	22 bytes	SEND_PARAMETERS (50004)

STORE_ PARAMETERS	50005 (0xc355)	0	Acknowledge: STORE_ PARAMETERS with no data (50005)
RESET_MDI_COUNTER	50014 (0xc35e)	0	Acknowledge: RESET_MDI_ COUNTER with no data (50014)
RESET_HEARTBEAT_ COUNTER	50015 (0xc35f)	0	Acknowledge: RESET_ HEARTBEAT_COUNTER with no data (50015)
RESET_EMERGENCY_ COUNTER	50017 (0xc361)	0	Acknowledge: RESET_ EMERGENCY_COUNTER with no data (50017)
SET_LED	50040 (0xc378)	4 bytes	Acknowledge: SET_LED with no data (50040)

The format of frames from the host to the FLATSCAN is presented below:

Host to FLATSCAN frame					
SYNC	CMD	data			CHK
		D0	…	Dn	
11bytes	2bytes	0 to 22 bytes			2 bytes

3.2.1 SET_BAUDRATE

The message SET_BAUDRATE is used to modify the baud rate of the serial communication. The new value is automatically saved in EEPROM and the baud rate is modified at the next power on. The acknowledge message contains the data of the SET_BAUDRATE command if the value is valid. In case the value is not valid, the data is replaced by 255 (0xff).

Message from host	SET_BAUDRATE Define the baud rate of the serial communication
SYNC	General format
CMD	50001 (0xc351)
Data (1 byte):	
D0	Baudrate: • 0 : 57600 • 1 : 115200 • 2 : 230400 • 3 : 460800 • 4 : 921600 Take into account the quantity of data and the period of the transmission in HS and HD modes: if the baud rate is not sufficient, measurement information is lost.
CHK	General format
FLATSCAN answer	Acknowledge: SET_BAUDRATE (50001)

3.2.2 GET_MEASUREMENTS

The message GET_MEASUREMENTS is used for requesting MDI frame and define the transmission mode:

- Single shot mode: only one single complete MDI frame is sent after the request.
- Continuous mode: MDI frames are sent periodically (D0 = 1).

By default, the FLATSCAN is in continuous mode, sot the GET_MEASUREMENTS message is not necessary for starting the transmission of measurements.

Message from host		GET_MEASUREMENTS Define single shot or continuous transfer
SYNC		General format
CMD		50011 (0xc35b)
Data (1 byte):		
D0		Measurement transfer mode: • 0 : single shot • 1 : continuous
CHK		General format
FLATSCAN answer		MDI frame

3.2.3 GET_IDENTITY

The message GET_IDENTITY is used to read out the parameters of the FLATSCAN.

Message from host	GET_IDENTITY Read out identity of the FLATSCAN
SYNC	General format
CMD	50010 (0xc35a)
Data (0 byte)	-
CHK	General format
FLATSCAN answer	SEND_IDENTITY (50010)

3.2.4 GET_EMERGENCY

The message GET_EMERGENCY is used to check the emergency status of the FLATSCAN.

Message from host	GET_ EMERGENCY Check emergency status of the FLATSCAN
SYNC	General format
CMD	50030 (0xc36e)
Data (0 byte)	-
CHK	General format
FLATSCAN answer	EMERGENCY (50030)

3.2.5 GET_PARAMETERS

The message GET_PARAMETERS is used to read out the parameters of the FLATSCAN.

Message from host	GET_PARAMETERS Read out FLATSCAN parameters
SYNC	General format
CMD	50004 (0xc354)
Data (0 byte)	-
CHK	General format
FLATSCAN answer	SEND_PARAMETERS (50004)

3.2.6 SET_PARAMETERS

The message SET_PARAMETERS is used to configure all the FLATSCAN parameters.

Message from host	SET_PARAMETERS Configure the FLATSCAN parameters
SYNC	General format
CMD	50003 (0xc353)
Data (22 bytes) :	
D0	Reserved for future use, write 0.
D1	CTN field in measurement frames (temperature): • 0 : disable • 1 : enable
D2	Information in MDI: • 0 : send distances only • 1 : send remissions only • 2 : send distances and remission
D3	Detection field mode • 0 : HS (high speed) • 1 : HD (high density)
D4	Sensitivity and immunity optimization with respect to the size of the detection field (maximum distance): • 0 : no optimization (maximum sensitivity) • 1 : range = 0 to 2.5m (minimum sensitivity) • 2 : range = 0 to 3.0m • 3 : range = 0 to 3.5m • 4 : range longer than 3.5m (maximum sensitivity)
D5 to D7	Reserved for future use, write 0.
D8, D9	Number of spots in the field. Take into account restrictions linked to HS and HD modes.
D10 to D13	Reserved for future use, write 0.
D14, D15	Angle_first: limit of the detection field (unit: 0.01°).
D16, D17	Angle_last: limit of the detection field (unit: 0.01°).
D18	CAN and frame counter fields in measurement, heartbeat, emergency frames: • 0 : disable • 1 : enable
D19	Heartbeat period (unit: 1 sec). Range: 0 to 255. If the value is 0, the heartbeat is disabled
D20	Facet number field in MDI. • 0 : disable • 1 : enable
D21	Averaging setting: • 0 : No averaging • 1 : averaging 3 points in time • 2 : averaging 3 points in time + 2 neighbours • 3 : averaging 5 points in time • 4 : averaging 5 points in time + 2 neighbours
CHK	General format
FLATSCAN answer	SEND_PARAMETERS (50004)

3.2.7 STORE_PARAMETERS

The message STORE_ PARAMETERS is used to store the parameters in the EEPROM of the FLATSCAN.

Message from host	STORE_ PARAMETERS
SYNC	General format
CMD	50005 (0xc355)
Data (0 byte)	-
CHK	General format
FLATSCAN answer	Acknowledge: STORE_ PARAMETERS (50005)

3.2.8 RESET_MDI_COUNTER

The message RESET_MDI_COUNTER is used to reset the counter of the MDI to 1.

Message from host	RESET_MDI_COUNTER
SYNC	General format
CMD	50014 (0xc35e)
Data (0 byte)	-
CHK	General format
FLATSCAN answer	Acknowledge: RESET_MDI_COUNTER (50014)

3.2.9 RESET_HEARTBEAT_COUNTER

The message RESET_HEARTBEAT_COUNTER is used to reset the counter of the heartbeat to 1.

Message from host	RESET_HEARTBEAT_COUNTER
SYNC	General format
CMD	50015 (0xc35f)
Data (0 bytes)	-
CHK	General format
FLATSCAN answer	Acknowledge: RESET_HEARTBEAT_COUNTER (50015)

3.2.10 RESET_EMERGENCY_COUNTER

The message RESET_EMERGENCY_COUNTER is used to reset the counter of the emergency to 1.

Message from host	RESET_EMERGENCY_COUNTER
SYNC	General format
CMD	50017 (0xc361)
Data (0 bytes)	-
CHK	General format
FLATSCAN answer	Acknowledge: RESET_EMERGENCY_COUNTER (50017)

3.2.11 SET_LED

The visible LED can be controlled using the SET_LED message.

Message from host	SET_LED
SYNC	General format
CMD	50040 (0xc378)
Data (4 bytes)	

D0	Action: • 1 : set LED (set also color1) • 2 : blink LED (set also color1, color2, frequency)
D1	Color 1: • 0 : OFF • 1 : red • 2 : green • 3 : orange
D2	Blink color 2 (ignored if action is 1): • 0 : OFF • 1 : red • 2 : green • 3 : orange
D3	Blink frequency in Hz (ignored if action is 1): Range: 1 to 10.
CHK	General format
FLATSCAN answer	Acknowledge: SET_LED with no data (50040)

3.3 Messages from FLATSCAN to host

The different messages that can be sent from FLATSCAN to the host are summarized in the table below. As the format of these frames is different for each of them, it is presented in dedicated paragraphs.

Message from FLATSCAN to host		
Frame	**CMD**	**Length of data**
MDI	50011(0xc35b)	Max 409 bytes or 1609 bytes
SEND_IDENTITY	50010 (0xc35a)	12 bytes
SEND_PARAMETERS	50004 (0xc354)	28 bytes
HEARTBEAT	50020 (0xc364)	0 to 6 bytes
EMERGENCY	50030 (0xc36e)	4 bytes

3.3.1 MDI (measured distances information)

MDI frames are sent by the sensor to the host. Depending on the parametrization of the sensor, the communication can be periodic or following a request from the host.
The format of a MDI frame is presented below, it can contain distances and/or remission information. The message SET_PARAMETERS is used to enable the optional fields.

MDI frame												
SYNC	CMD	data										CHK
		CAN	CNTR	CTN	Facet	distances			remissions			
						D0	…	Dn	R0	…	Rn	
11 bytes	2 bytes	4 bytes	2 bytes	2 bytes	1 byte	max 100x2bytes or 400x2bytes			max 100x2bytes or 400x2bytes			2 bytes
		optional		optional	optional	optional			optional			

Message from FLATSCAN	MDI - Measured distance information
SYNC	General format
CMD	50011 (0xc35b)
Data (max 409 bytes or 1609 bytes):	

CAN (4 bytes)	CAN number of the detector (BEA serial number).
CNTR (2 bytes)	MDI frames counter: indicates the number of complete MDI frames sent since the last power on or the last reset command (RESET_MDI_COUNTER). The maximum value for the counter is 65535. Afterwards, it restarts at 1.
CTN (2bytes)	Internal temperature of the detector head. The unit is 0.1°C. The coding is signed.
Facet (1byte)	Reference of the current mirror facet: 1, 2, 3, or 4 for HS mode, 5 for HD mode (interlacing).
Distances (max 100 x 2bytes or 400 x 2bytes)	Measured distances related to the referenced facet, coded on 2bytes for each spot. The unit is mm. The distances are sorted from the first spot (D0), defined by the parameter *first_angle*, to the last spot (Dn), defined by the parameter *last_angle*.
Remissions (max 100 x 2bytes or 400 x 2bytes)	Measured remissions related to the referenced facet, coded on 2bytes for each spot. The remissions are sorted from the first spot (R0), defined by the parameter *first_angle*, to the last spot (Rn), defined by the parameter *last_angle*.
CHK	General format

3.3.2 SEND_IDENTITY

When the sensor receives a GET_IDENTITY request, it answers with a SEND_IDENTITY message that allows the controller to check the hardware and software versions.

Send identity frame					
SYNC	CMD	data			CHK
		D0	…	D11	
11bytes	2bytes	12 bytes			2 bytes

Message from FLATSCAN	SEND_IDENTITY
SYNC	General format
CMD	50010 (0xc35a)
Data (12 bytes) :	
D0 to D3	Product part number (BEA TOF), for example 20077201
D4	Software version
D5	Software revision
D6	Software prototype
D7 to D10	CAN number of the detector (BEA serial number)
D11	0, reserved for future use
CHK	General format

3.3.3 SEND_PARAMETERS

When the sensor receives a GET_PARAMETERS request, it answers with a SEND_PARAMETERS message.

The SEND_PARAMETERS message is also used as acknowledge for the SET_PARAMETERS command.

The format of the SEND_PARAMETERS frame is presented below:

Send parameters frame					
SYNC	CMD	data			CHK
		D0	…	D27	
11bytes	2bytes	28 bytes			2 bytes

Message from FLATSCAN	SEND_PARAMETERS
SYNC	General format
CMD	50004 (0xc354)
Data (28 bytes) :	
D0 to D3	Verification bits: When the SEND_PARAMETERS message is used as acknowledge following a SET_PARAMETERS message, these verification bits give confirmation that the value configured by the controller is correct (bitx = 0). Verification bit set to 1 means that the associated parameter value is not valid. • Bit 0 : 0, reserved for future use • Bit 1 : enable CTN • Bit 2 : measurement information • Bit 3 : detection field mode • Bit 4 : sensitivity and immunity optimization • Bit 5 to bit 8 : 0, reserved for future use • Bit 9 : number of spots in the detection field • Bit 10, bit 11 : 0, reserved for future use • Bit 12 : angle_first • Bit 13 : angle_last • Bit 14 : CAN and CNTR fields • Bit 15 : heartbeat period • Bit 16 : facet field • Bit 17 : averaging setting • Bit 18 to 32 : 0, reserved for future use
D4, D5	Communication charge in %, computed based on the quantity of data and the period of the transmission. If the charge is more than 100%, it is not possible to transmit all information.
D6	0, reserved for future use.
D7	CTN field in measurement frames (temperature): • 0 : disabled • 1 : enabled
D8	Information in MDI: • 0 : send distances only • 1 : send remissions only • 2 : send distances and remission
D9	Detection field mode : • 0 : HS (high speed) • 1 : HD (high density)
D10	Sensitivity and immunity optimization with respect to the size of the detection field (maximum distance): • 0 : no optimization (maximum sensitivity) • 1 : range = 0 to 2.5m (minimum sensitivity) • 2 : range = 0 to 3.0m • 3 : range = 0 to 3.5m • 4 : range longer than 3.5m (maximum sensitivity)
D11 to D13	0, reserved for future use.

D14, D15	Number of spots in the field.
D16 to D19	0, reserved for future use.
D20, D21	Angle_first: limit of the detection field (unit: 0.01°).
D22, D23	Angle_last: limit of the detection field (unit: 0.01°).
D24	CAN and frame counter fields in measurement, heartbeat, emergency frames: • 0 : disable • 1 : enable
D25	Heartbeat period (unit: 1 sec). Range: 0 to 255. If the value is 0, the heartbeat is disabled
D26	Facet number field in MDI: • 0 : disable • 1 : enable
D27	Averaging setting: • 0 : No filter • 1 : averaging 3 points in time • 2 : averaging 3 points in time + 2 neighbours • 3 : averaging 5 points in time • 4 : averaging 5 points in time + 2 neighbours
CHK	General format

3.3.4 HEARTBEAT

The FLATSCAN can send a periodic heartbeat message to allow monitoring by the host.
The period of the heartbeat is defined with *heartbeat_period* parameter. If *hearbeat_period* is 0, the heartbeat is disabled. The format of the heartbeat frame is presented below. The command SET_PARAMETERS is used to enable the optional fields.

Heartbeat frame				
SYNC	CMD	data		CHK
		CAN	CNTR	
11bytes	2bytes	4 bytes	2 bytes	2 bytes
		optional		

Message from FLATSCAN	HEARTBEAT
SYNC	General format
CMD	50020 (0xc364)
Data (6 bytes) :	
CAN (4 bytes)	CAN number of the detector (BEA serial number).
CNTR (2 bytes)	Heartbeat counter, indicates the number of heartbeat frames sent since the last power on or the last reset command (RESET_HEARTBEAT_COUNTER). The maximum value for the counter is 65535. Afterwards, it restarts at 1.
CHK	General format

3.3.5 EMERGENCY

The emergency messages are sent by the FLATSCAN to the controller in case an internal error is detected. Emergency message can also be requested by the controller to check the emergency status of the FLATSCAN.

Emergency message is sent spontaneously at the moment the error is detected. In case the failure is related to an integrity test, the sensor is automatically reset after 15 sec, trying to recover a normal function. The emergency message is sent before the reset.
The format of the emergency frame is presented below:

Emergency frame								
SYNC	CMD	data						CHK
		CAN	CNTR	emergency				
				D0	D1	D2	D3	
11 bytes	2 bytes	4 bytes	2 bytes	4 bytes				2 bytes
		optional						

Message from FLATSCAN	EMERGENCY
SYNC	General format
CMD	50030 (0xc36e)
Data (4 bytes) :	
CAN (4bytes)	CAN number of the detector (BEA serial number).
CNTR (2 bytes)	Emergency counter, indicates the number of emergency frames sent since the last power on or the last reset command (RESET_EMERGENCY_COUNTER). The maximum value for the counter is 65535. Afterwards, it restarts at 1.
D0, D1	Error code relative to the RS485 module, 0x0000 if no error detected.
D2, D3	Error code relative to the measuring head, 0x0000 if no error detected.
CHK	General format

Emergency messages – codes and actions		
Error in the RS485 module	**Error code (D0, D1)**	**action**
Integrity test failure in RS485 module	0x8001 to 0x80aa	Emergency message and reset.
Hardware failure in the RS485 module	0x500d	
Input supply low or high	0x500a	Emergency message, stop MDI messages
No error detected in the RS485 module	0x0000	No spontaneous action
Error in the measuring head	**Error code (D2, D3)**	**action**
Integrity test failure in the measuring head.	0x8001 to 0x80aa	Emergency message and reset.
Hardware failure in the measuring head	0x5001 to 0x5020	
Communication error between head and RS485 module	0x8101, 0x8104	Emergency message, stop MDI messages
No error detected in the measuring head	0x0000	No spontaneous action

4. CRC code

The verification field of the frame is a CRC16.
The properties of the CRC processing are presented below:

- All bytes of the SYNC, CMD, and DATA and the message are considered for computing the CRC
- The polynomial is 0x90d9
- Preset value is 0

A source code for computing the CRC is proposed below:

```
#define BYTE unsigned char
#define WORD unsigned short
#define BEA_POLYNOM 0x90d9

WORD CRC16(BYTE *buf_,WORD cnt_)
{
   WORD crc = 0; /* CRC value is 16bit */
   WORD i, j;

   for(i = 0; i < cnt_; i++)
   {
      crc ^= (WORD)(buf_[i] << 8); /* move byte into MSB of 16bit CRC */

      for (j = 0; j < 8; j++)
      {
         if ((crc & 0x8000) != 0) /* test for MSB = bit 15 */
         {
            crc = (WORD)((crc << 1) ^ BEA_POLYNOM);
         }
         else
         {
            crc <<= 1;
         }
      }
   }

   return crc;
}
```