

**SYMEO LPR®**

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Protocol Description Binary XP



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# 1 Protocol Binary XP Description

## 1.1 General Description

This protocol describes the interface between a LPR<sup>®</sup>-B station and the user. The binary protocol XP protocol provides information in high density. Its structure ensures a simple implementation. The transfer is done in single data frames.

The interface for the binary protocol XP can either be a serial (RS232) interface or a TCP/IP or UDP interface. If the serial interface is chosen the data rate can be programmed to standard values (115200, 38400, 19200, 9600 baud). If a low data rate is chosen the measurement rate of the LPR<sup>®</sup>-B system may be adapted.

### 1.1.1 Direction of Data

The interface can be applied bidirectional. However certain data types are defined for one direction. Furthermore it is only allowed to send data to a LPR<sup>®</sup>-B station after the LPR<sup>®</sup>-B station has sent a send request. Table 1 shows an overview which data packets can be applied in which direction.

Data Type	direction	
	from LPR <sup>®</sup> - B	To LPR <sup>®</sup> - B
0x00 Distance Data	+	
0x01 User Data	+	+
0x02 Send Request	+	
0x03 Relay Switching Command		+
0x04 6-Channel Distance Data Set	+	
0x05 Cell Coordinates	+	
0x06 Self Organizing		+
0x07 Cell Information	+	
0x08 Configuration of Cell Measurement		+
0x09 Request of Parameters		
0x10 Answer of parameters		

Tab. 1: direction of data

To send data to the LPR<sup>®</sup>-B station is only possible after receiving a send request (Type 0x02). The send request type guarantees the "ready-to-receive" status of the LPR<sup>®</sup>-B station. The LPR<sup>®</sup>-B can only handle one data packet from one user.

If nevertheless data is sent to the LPR<sup>®</sup>-B station without a previous send request, it can result in a reboot of the LPR<sup>®</sup>-B station.

Per one send request you can send one data set to the LPR<sup>®</sup>-B station.

### 1.1.2 Structure of Data Packet

To apply the protocol on a RS232 interface each data packet starts and ends with a reserved symbol. This reserved symbol cannot appear in the data stream.

Figure 1 shows the general structure of the data packet.



Figure 1: Structure of data the packet

The START and the STOP-field is in each data packet the reserved symbol 0x7e and 0x7f. TYPE indicates the type of the data packet. There can be defined up to 256 different types. The TYPE-field is following the DATA-field. The DATA field contains the real data of the packet of the type TYPE. The CRC-field contains a check sum. The check sum is applied to all previous data fields except the START data field.

All multi byte integers (e.g. CRC field) are encoded in Network-Byte-Order (Big Endian).

### 1.1.3 Byte Stuffing

The two symbols 0x7E and 0x7F are unique for START and STOP-fields. If those symbols occurs within any other field (TYPE, DATA or CRC), they must be replaced by the following order:

original symbol	replaced by
0x7D	0x7D 0x5D
0x7E	0x7D 0x5E
0x7F	0x7D 0x5F

This byte stuffing scheme ensures that the receiver of the protocol can identify definitely the START-field within a flow of data, even if the symbol of the start field occurs within the DATA-field.

Example: If the symbol 0x7d is read, it must be cancelled. The following symbol must be XOR combined with 0x20 to recreate the original symbol.

Remark: Byte stuffing is deactivated for the fixed frame protocol (compare chapter 1.3).

### 1.1.4 CRC

The CRC-16-IBM with polynomial  $x^{16}+x^{15}+x^2+1$  is used for the CRC. The CRC is calculated over all data fields (TYPE and DATA), but not for the START and END field.

The CRC-calculation is only applied to the original symbols. The appropriate calculation for coding must applied before byte stuffing. If receiving the data from the LPR®-B system the byte stuffing must be reserved to get the original symbol. Then the CRC is updated with the original symbol.

## 1.2 Data Types

The second byte in each data packet specifies the data type. Type 0x04, Type 0x05, Type 0x06, Type 0x07, Type 0x08, Type 0x09, Type 0x10 are only used for 2D applications.

### 1.2.1 Type 0x00 – Distance Data

Direction: LPR®-B → User

Content	Length	Value	Data type
START	1	0x7E	
TYPE	1	0x00	
Source* (LPR® address <sup>1.4.1</sup> )	2	0x####	see chapter 1.4.1
Destination* (LPR® address <sup>1.4.1</sup> )	2	0x####	see chapter 1.4.1
Antenna number**	1	0x##	unsigned integer
Distance [mm]	4	0x#### #####	signed integer
Velocity [mm/s]	4	0x#### #####	signed integer
Level [dB]	1	0x##	signed integer
Error	1	0x##	unsigned integer
Status	1	0x00	unsigned integer
CRC	2	0x####	
END	1	0x7F	

Total length without byte stuffing: 21 byte

\*) Any measurement is always executed by a LPR®-B base station, this means, the base station measures its distance etc. towards a transponder unit. The source field always contains the address of the LPR®-B base station. The destination field contains the address of the measured transponder. Even if the data set is transferred further on to another unit (e.g. another transponder), the value of the source and destination field is maintained.

\*\*) The field antenna contains the antenna number of the base station as well as the antenna number of the measured transponder. The 4 lower bits represent the antenna number of the base station (values 1...4) and the higher ones the antenna number of the transponder (values 1...4).

#### 1.2.1.1 Example of Distance Data

```
7E 02 C1 81 7F
7E 00 08 03 08 02 11 00 00 10 62 00 00 00 7A E6 00 00 AF C4 7F
```

Figure 1 - Protocol for a single 1D measurement: request data and following distance data

This protocol shows a simple example for 1D measurement. A distance data set (or also 2 distance data sets) alternate with a send request. The Send Request indicates that the LPR® unit is listening to a data set from the user (for example relays external commands). The Distance Data sends the data to the user (i.e. to a PLC or to a PC/software).

Send request:

7E 02 C1 81 7F

- 7E<sub>hex</sub>      START byte
- 02<sub>hex</sub>      TYPE (02; Send Request)
- C1 81<sub>hex</sub>    cyclic redundancy check
- 7F<sub>hex</sub>      END byte

**Distance date:**

7E 00 08 03 08 02 11 00 00 10 62 00 00 00 7A E6 00 00 AF C4 7F

- 7E<sub>hex</sub>      START byte
- 00<sub>hex</sub>      TYPE (00: Distance Data)
- 08 03<sub>hex</sub> = 00001|0000000001|1<sub>bin</sub>    Source LPR® address: GID: 1; SID: 1; BBt: 1 (master unit/transponder)
- 08 02<sub>hex</sub> = 00001|0000000001|0<sub>bin</sub>    Destination LPR® address: GID: 1; SID: 1; BBt: 0 (slave unit/ base station)
- 11<sub>hex</sub> = 0001|0001<sub>bin</sub>                  Antenna port base station: 1 antenna port transponder: 1
- 00 00 10 62<sub>hex</sub> = 4194<sub>dec</sub>                  Distance: 4194 mm
- 00 00 00 7A<sub>hex</sub> = 122<sub>dec</sub>                  Velocity: 122 mm/s
- E6<sub>hex</sub> = 230<sub>dec</sub>                              Level: 230 – 256 = -26 dB
- 00<sub>hex</sub>      Error status: 0 means no error; unequal 0 means error
- 00<sub>hex</sub>      Status
- AF C4<sub>hex</sub>    cyclic redundancy check
- 7F<sub>hex</sub>      END byte

**1.2.2      Type 0x01 – User Data**

User Data can be integrated at a LPR®-B station via the serial interface and then transmitted to another LPR®-B station via the frequency channel. There the user data can be readout.

Direction: LPR®-B → User

Content	Length	Value
START	1	0x7E
TYPE	1	0x01
Source (LPR®-B address <sup>1.4.1</sup> )	2	0x#####
User Data	8	0x##### ##### ##### #####
CRC	2	0x#####
END	1	0x7F

Total length without byte stuffing: 15 byte

User data can be integrated at a LPR® station and can be transmitted via the frequency channel to another LPR® station.

### 1.2.3 Type 0x02 – Send Request

Direction: LPR®-B → User

Content	Length	Value
START	1	0x7E
TYPE	1	0x02
CRC	2	0xC181
END	1	0x7F

Total length without byte stuffing: 5 byte

This packet is sent from the LPR®-B station continuously. It informs the user that the LPR®-B station is able to receive data from the user. The user may only send one single data frame after receiving a send request.

### 1.2.4 Type 0x03 – Relays Switching Command

Direction: User → LPR®-B

Content	Length	Value	Data type
START	1	0x7E	
TYPE	1	0x03	
Destination (LPR®-B address <sup>1.4.1</sup> )	2	0x####	see chapter 1.4.1
Relay Selection (Bitmask) (bit 1..7 → relay 1..7)	1	0x##	unsigned integer
Relay Switch (Bitmask)	1	0x##	unsigned integer
CRC	2	0x####	
END	1	0x7F	

Total length without byte stuffing: 9 byte

With the relay selection (bitmask) relays are selected which can be controlled. The relays that are chosen within the Relay Selection bitmask will be switched according to the Relay Switch bitmask  
 Example: A Relay Selection value =  $0x14_{hex} = 00010100_{bin}$  and a Relay Switch value =  $0xFF_{hex} = 11111111_{bin}$  will switch relays 2 and 4 ON - the state of the other relays remains unchanged.

No acknowledgment of the relay switch command will be sent because this data frame can be forwarded to other LPR®-B stations and thus no reception on the destination station is guaranteed. In case of faulty data frame (e.g. invalid relays chosen or unknown destination address) the LPR®-B station will print an error message.

### 1.2.5 Type 0x04 – 6 Channel Distance Data Set

Direction: LPR®-B → User

Description	Length	Value	Data type
-------------	--------	-------	-----------

START	1	0x7E	
TYP	1	0x04	
Source <sup>1</sup> (LPR <sup>®</sup> -B address <sup>1.4.1</sup> )	2	0x#####	See chapter 1.4.1
Antenna number <sup>2</sup>	1	0x##	unsigned integer
Group	2	0x#####	unsigned integer
Measurement Channel 0 <sup>3</sup>	12		see below
Measurement Channel 1	12		see below
Measurement Channel 2	12		see below
Measurement Channel 3	12		see below
Measurement Channel 4	12		see below
Measurement Channel 5	12		see below
Age of Measurement [µs]	4	0x##### #####	unsigned integer
Configuration <sup>4</sup>	1	0x00	
Iteration counter <sup>5</sup>	1	0x#####	Unsigned integer
CRC	2	0x#####	
END	1	0x7F	

Total length without byte stuffing: 89 byte

<sup>1)</sup> a) regular LPR<sup>®</sup>-B mode (RTOF mode): A measurement is always started by a LPR<sup>®</sup>-B base station and the base station measures its distance to a transponder. The source field contains the LPR<sup>®</sup>-B address of the base station. The destination field contains the address of the transponder. If the data is transmitted to another station in the LPR<sup>®</sup>-B system the source and destination field is kept.

b) TDOA mode: The source-field contains always the LPR<sup>®</sup>-B address of the reference station (Master station or master base station)

Source field see chapter 1.2.1

<sup>2)</sup> Antenna number <sup>5</sup> contains the number of the antenna of the slave station/ base station (values: 1...4)

<sup>3)</sup> The measurement of the single channels is similar to the distance data set (see chapter 1.2.1):

Distance [mm]	4	0x##### #####	signed integer
Velocity [mm/s]	4	0x##### #####	signed integer
Attenuation [dB]	1	0x##	signed integer
Error <sup>6</sup>	1	0x##	unsigned integer
Quality Criterion	2	0x#####	unsigned integer

<sup>4)</sup> Status of the configuration of the LPR<sup>®</sup>-B station → Status=0: Mode as RTOF System; regular LPR<sup>®</sup>-B mode (distances are transmitted), Status=1: mode as TDOA System (time difference of distances are transmitted)

<sup>5)</sup> 15-Bit field –is incremented at each measurement

<sup>6)</sup> a value of 0 indicates a valid measurement, value=8 indicates a walking Master in a TDOA System with multiple cells. All other values indicates an error = invalid measurement.

### 1.2.6 Type 0x05 –Coordinates of cell

Direction: LPR®-B → User

Content	Length	Value	Data type
START	1	0x7E	
TYP	1	0x05	
Source <sup>1</sup>	2	0x#####	
Number of transponders per cell <sup>2</sup>	1	0x##	
Independent coordinate system <sup>3</sup>	1		
Station ID <sup>4</sup>	1	0x##	unsigned integer
x – coordinate [mm]	4	signed	signed integer
y – coordinate [mm]	4	signed	signed integer
Altitude [mm]	2	signed	signed integer
x – direction vector	1	signed	signed integer
y – direction vector	1	signed	signed integer
Aperture angle of antenna [°]	2	unsigned	unsigned integer
FSK channel <sup>5</sup>	1	• 0x##	unsigned integer
RSSI-level	1	• 0x##	signed integer
Cell type <sup>6</sup>	1	• 0x##	
CRC	2	0x#####	
END	1	0x7F	

Total length without byte stuffing: 27 byte

This data set is sent for each transponder per cell.

<sup>1)</sup> Source field: Different to other message types the source type is in this case the LPR® address of the master.

<sup>2)</sup> Maximum of 6 transponders per cell are possible

<sup>3)</sup> The coordinate system indicates if the cell has an own coordinate system (1) with no fixed relation to another cell or if the cell is a part of a superior coordinate system, which consists of multiple cells (0). This is important for the demonstration in SYMEO Map.

<sup>4)</sup> The Stations-ID<sup>1.4.1</sup> is equal to the measurement channel (0..5) of the according transponders. Coordinates of the master can also be transmitted. The master has the station-ID 30 (0x1e). If also master coordinates are transmitted, the number in the “field number of transponder in cell 1” increases by one.

<sup>5)</sup> The frequency channel (communication channel) of corresponding cell

<sup>6)</sup> Type of cell: 0=fixed TDOA-cell, 1=mobile TDOA-cell, 2=conventional cell

### 1.2.7 Type 0x06 – Self Organizing

Direction: User → LPR®-B

Content	Length	Value
START	1	0x7E
TYP	1	0x06
Source	2	0x####
Number of measurement	2	0x####
Flags <sup>1</sup>	2	0x0000
CRC	2	0x####
END	1	0x7F

Total length without byte stuffing: 11 Byte

The packet starts a series of measurements between the transponders of a cell. The results are sent as 6-channel distance data set (type 0x04).

<sup>1</sup>) Flags: for future expansion, at the moment always zero

### 1.2.8 Type 0x07 – Cell Information

Direction: User → LPR®-B

Description	Length	Value
START	1	0x7E
TYP	1	0x07
Source <sup>1</sup>	2	0x####
FSK-channel <sup>2</sup>	1	unsigned integer
RSSI-level	1	signed integer
Status of transponder <sup>3</sup>	4	0x#####
CRC	2	0x####
END	1	0x7F

Total length without byte stuffing: 13 Byte

<sup>1</sup>) Source-field: see data type 0x05 (1.4.1)

<sup>2</sup>) FSK-channel (communication channel) of corresponding cell

<sup>3</sup>) Error status of cell – not yet implemented

### 1.2.9 Type 0x08 – Configuration of Cell Measurement

Direction: User → LPR®-B

Description	Length	Value
-------------	--------	-------

START	1	0x7E
TYP	1	0x08
Measurement 1 - Cell-ID <sup>1</sup>	2	unsigned integer
Measurement 1 - FSK-channel	1	unsigned integer
Measurement 1 – Antenna mask <sup>2</sup>	1	0x##
Measurement 2 - measurement -ID <sup>1</sup>	2	unsigned integer
Measurement 2 - FSK- channel	1	unsigned integer
Measurement 2 - Antenna mask <sup>2</sup>	1	0x##
Measurement 3 - measurement -ID <sup>1</sup>	2	unsigned integer
Measurement 3 - FSK- channel	1	unsigned integer
Measurement 3 - Antenna mask <sup>2</sup>	1	0x##
Measurement -ID <sup>1</sup> to be scanned	2	unsigned integer
FSK- channel to be scanned	1	unsigned integer
Antenna mask <sup>2</sup> to be scanned	1	0x##
CRC	2	0x#####
END	1	0x7F

Total length without byte stuffing: 21 Byte

This data packet indicates which measurements can be executed by the Managed-Cell base station. This base station is told with which cell it is allowed to measure. At maximum 3 cells are possible. If the corresponding cell-ID is set to 0 this measurement (1, 2, or 3) does not participate in the measurement cycle. If all cell-IDs are set to 0 no measurement is taken. In this case the base station scans the frequency channels.

The field FSK-channel indicates the FSK channel of the corresponding cell. The field antenna mask indicates which antennas (1...4) are used in this cell.

Beside the measurement the base station is also scanning the frequency channels. A cell can be specified in the data field “FSK-channel to be scanned” which can be scanned with higher priority.

<sup>1)</sup> Cell-ID: Group-ID of corresponding cell (values: 1...1022)

<sup>2)</sup> Antenna mask: Bits 0...3 (relates to 1...4) indicates if the corresponding antenna is allowed to measure (Bit is set = Antenna is allowed to measure)

### 1.2.10 Type 0x09 – Request of Parameters

Direction: User → LPR®-B

Description	Length	Value
START	1	0x7E
TYP	1	0x09

Parameter Index	2	unsigned integer
Flag	1	unsigned integer
CRC	2	0x####
END	1	0x7F

Total length without byte stuffing: 8 Byte

This packet is sent from the user to LPR®-B station to request single parameters of the LPR®-B configuration. The LPR®-B answers with data type 0x10.

### 1.2.11 Type 0x10 – Answer of Parameters

Direction: User → LPR®-B

Description	Length	Value
START	1	0x7E
TYP	1	0x10
Parameter Index <sup>1</sup>	2	unsigned integer
Flag <sup>1</sup>	1	unsigned integer
Value of parameters	4	0x#####
CRC	2	0x####
END	1	0x7F

Total length without byte stuffing: 12 Byte

This data packet contains information about the configuration of the LPR®-B station. It contains the allocation of the parameter which is sent to the LPT-B station at last (type 0x09). The data type of the parameter depends on the parameter index. A list of all parameters is described in chapter 1.4.2.

<sup>1</sup>) Parameter Index and Flag from parameter request (Type 0x09)

## 1.3 TCP/IP option: Fixed Frame Protocol

If the LPR® station has a TCP/IP interface two options are available for the protocol. Either you use the protocol as it is sent from the serial interface (with different data type lengths, byte stuffing) or you use a fixed frame protocol.

In the first case the data symbols 0x7e und 0x7f (which are reserved for the START and END field) are replaced (see chapter 1.1.3). Byte stuffing causes a different protocol length.

For the fixed frame protocol each LPR® data packet is filled up with zero bytes to a fixed length of bytes (i.e. 87 bytes) before the data packet is sent. Byte stuffing does not occur. The START and the END byte are still used but not clear anymore due to not applying byte stuffing. The fixed length of the data packets can be set on the web-interface of the LPR® unit.

For the fixed frame protocol the data packets which are sent to a LPR® unit has to be filled up to a fixed length (i.e. 15 bytes). The START- and the END byte have to be occurred as well

and byte stuffing does not occur anymore. It is recommended to fill up the data packet with zero bytes to facilitate a troubleshooting.

If TCP/IP is used the transmitted data have already a checksum. Therefore the checksum in the protocol is not as important as for the serial interface. Two options for the fixed frame are allowed by the protocol inverter for receiving data in a fixed frame. Either 0x0000 is sent as the check sum to the LPR® unit. Then the protocol inverter is calculating the check sum itself. Or another value (differing to 0x0000) is sent as the check sum. Then this check sum is assumed to be the correct check sum. Otherwise the data packet is rejected.

### 1.3.1 Detailed description TCP Fixed-Frame Protocol

If a TCP fixed-frame protocol is used, a working TCP connection between the PC and the LPR® unit has to be guaranteed. Depending on the configuration of the LPR® protocol inverter either the connection to a port on the LPR® has to be initialized from the PC or the LPR® unit is establishing a connection to a PC.

If the connection is established, the PC has to read the data from the LPR® in fixed data length (i.e. 87 bytes). The first byte is always the START-byte and the second byte is always the TYPE-byte. The relevance of the following data is depending on the data type. Because no byte stuffing occurs the content for a special data type is always constant. For example the measured velocity of the distance data (type 0x00) is always written in the 12.-15 data byte.

Sending data from the PC to LPR® station, a fixed data length has to be chosen (i.e. 15 byte). The first byte (START byte: 0x7e) follow the TYPE-byte. The following data depends on the chosen type, following by the CRC (correct CRC or 0x0000), following by the STOP byte (0x7f). The data packed has to be filled up with zeros.

#### Detailed description UDP Fixed-Frame Protocol

If a UDP fixed frame protocol is used, the IP and the UDP port of the PC has to be configured in the LPR® protocol inverter. The converter sends each data packet as a UDP packet of a fixed length (87 byte) to the PC. Compared to the TCP fixed frame option the UDP fixed frame does not verify if the data packed arrived.

The content is the same as for the TCP fixed frame protocol.

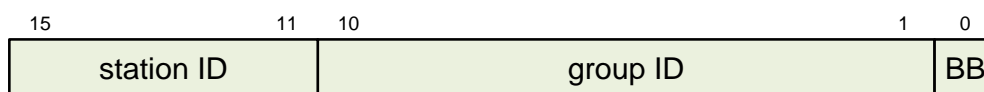
If data is sent to the LPR® unit the data has to be packed in a fixed data length (i.e. 15 bytes as for TCP fixed frame option). This data packet is sent as UDP packet to the LPR® unit. The port number of the receiver is the same as for the PC.

In general bidirectional data communication is not recommended for UDP due to loosing singular data packets.

## 1.4 Remarks

### 1.4.1 LPR®-B Address

LPR®-B station addresses are completely defined by a 16 bit value:



**BB – Base station Bit:** Indicates, if the LPR® station is defined as a slave unit/ base station or as a master unit/ transponder (1=base station, 0=transponder)

group ID: group ID of the station (1..1022)

station ID: station ID of the station (0..30)

### 1.4.2 Error messages

The distance data contains an error field which indicates the status of the message. The following errors can occur:

Content	Source	Description	Value
no error		Measurement valid	0x00
no peak detected	Base Station	No measurement signal	0x01
peak too low	Base Station	Measurement signal is imprecise	0x02
nothing received	Transponder	No measurement data received	0x03
implausible speed	Base Station	Velocity is to high	0x04
measurement botched	Base Station	Measurement is not feasible.	0x05
no occupying received	Master Transponder	Measurement channel is not reserved	0x06
no results received	Master Transponder	No measurement data received	0x07
trigger	Transponder	Unit did not attend the measurement	0x08