

1. The new binary interface protocol

This document is meant for ZIMO users who wish to use self programmed software....

Please Note: Content marked with (Version x) describes functionality available since protocol version x.

Version 5 is introduced with MX1 software version 3.06.

1. Communication basics:

The basic communication format is N,8,1 (no parity, 8 data bits, 1 stop bit). Communication speed ranges from 1200 to 38400 bit/s and can be selected via CV12. The default value is 9600 bit/s.

2. Flow control

Flow control is done via hardware (RTS/CTS). It is necessary to use a serial cable with at least 5 wires which also connects the RTS and CTS lines between PC and command station. Hardware flow control can be disabled by setting CV13 to 0. Default value is 1 (hardware flow control enabled).

3. The new binary communication

The new binary communication consists of data frames with the following structure:

- long frames:

```
<SOH><SOH>headerinfo_and_data[checksum16]<EOT>
```

- short frames (for frames of maximum 15 bytes):

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<SOH><SOH>headerinfo_and_data[checksum8]<EOT>
```

To establish a data transmission independent of content, all data (including headerinfo and checksum) characters identical to control characters have to be protected with the additional escape character prefix <DLE> and the character itself is XOR'ed with 0x20.

control character	value	replacement within data	description
<SOH>	0x01	<DLE>(<SOH>^0x20)	start of a data frame
<EOT>	0x17	<DLE>(<EOT>^0x20)	end of data frame
<DLE>	0x10	<DLE>(<DLE>^0x20)	escape character

Each data frame is immediately acknowledged by the receiver (level 1 reply). This reply may contain the appropriate data if it's immediately available in the command station. Otherwise the request is passed on via the CAN bus (to another station for example) and the subsequent incoming data is returned (level 2 reply).

Please note: Future expansions of single messages may involve additional bytes added to the frame.

3.1. Header info

The header info describes the meaning of the data content of a frame. The length of the header info is between 2 and 15 bytes. The first byte is the unique sequence-ID of the frame and must not be identical in two different consecutive frames. If a frame has to be repeated the sequence-ID remains unchanged. The second byte specifies the message type and the meaning of additional header bytes. Most messages are identified by the contents of the 2nd and 3rd header byte. The 2nd byte provides some kind of routing information the 3rd byte identifies a specific message. Together these two bytes might be considered as unique 16 bit message identifier.

common information in header byte 2:

bit(s)	value	description
7	0	short frame protocol message
	1	long frame protocol message
6 - 5	00	"primary" message – identified by bits 4-0 and byte 3
	10	acknowledgement / reply level 1
	01	reply level 2
	11	acknowledgement for level 2 reply
4	0	message sent by command station
	1	message sent by PC
3 - 0	0	message to/from command station (MX1)
	1	message to/from accessory module (MX8)
	2	message to/from track section module (MX9)

Bits 4-0 may alternatively considered to be a 5 bit part of the unique message identifier. It should not be taken for granted that "useless" bit combinations involving bit 4 strictly interpreted as origin identifier that are not used at this stage might not be assigned some other meaning some day.

3.1.1. short frame protocol messages

general messages

acknowledgement/reply sent by command station (level 1)

header byte	Value	description
1	0-255	unique sequence-ID
2	0100xxxx	acknowledgement/reply sent by command station (level 1)
3	XXX	same as primary message
4	ID	sequence-ID of the message that is being acknowledged
5..15	data	optional: requested data or additional return code

Reply: n.a.

acknowledgement/reply sent by PC (level 1)

header byte	value	description
1	0-255	unique sequence-ID
2	0101xxxx	acknowledgement/reply sent by PC (level 1)
3	XXX	same as primary message
4	ID	sequence-ID of the message that is being acknowledged
5..15	data	optional: requested data or additional return code

Reply: n.a.

acknowledgement/reply sent by command station (level 2)

header byte	value	description
1	0-255	unique sequence-ID
2	0010xxxx	acknowledgement/reply sent by command station (level 2)
3	XXX	same as primary message
4	ID	Sequence-ID of the message that is being acknowledged
5..15	data	optional: requested data

Reply: Ack (level 1)

acknowledgement/reply sent by PC (level 2)

header byte	value	description
1	0-255	unique sequence-ID
2	0x10	command station instruction
3	2	track control

1	0-255	unique sequence-ID
2	0011xxxx	acknowledgement/reply sent by PC (level 2)
3	XXX	same as primary message
4	ID	sequence-ID of the message that is being acknowledged
5..15	data	optional: requested data

Reply: Ack (level 1)

command station messages

These messages provide communication with the command station.

reset message

header byte	value	description
1	0-255	unique sequence-ID
2	0x00 0x10	command station instruction (sent by command station) (sent by PC)
3	0	reset message

Reply: Ack (level 1)

negative acknowledgement sent by command station

header byte	value	description
1	0-255	unique sequence-ID
2	0x00 0x10	command station instruction (sent by command station) (sent by PC)
3	1	negative acknowledgement

Reply: n.a.

track control

header byte	value	description
1	0-255	unique sequence-ID
2	0x10	command station instruction
3	2	track control

4	cAction	0 stop broadcast (stops all locos) 1 switch track voltage OFF 2 switch track voltage ON and re-enable broadcast 3 query status
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Reply: Ack (level 1)

return code	Value	Description
StatusBits	dm000uts	d DCC (1 on, 0 off) m Motorola (1 on, 0 off) u UES (1 UES on, 0 UES off) t track voltage (1 off, 0 on) s broadcast stop (1 on, 0 off)

loco control

(Version 5) With Version 5 an emergency stop is executed when the MSB of the speed step value is set. Additionally data bytes 7-9 are optional. If these values are omitted non of the bits will be altered.

header byte	value	description
1	0-255	unique sequence-ID
2	0x10	command station instruction
3	3	loco control
4	cAdr_hi	loco address high byte bit 6 + bit 7 format specifications (see 4.5)
5	cAdr_lo	loco address low byte
6	cSpeed	Speed step in the actual speed step system If bit 7 is set: emergency stop (DCC data signal: 0-14, 0-28 or 0-126; according to bit 3/2 in cData1;MOTOROLA protocol: 0-14)
7	cData1	optional: bit 7: MAN (override signal controlled speed limit) bit 6: no function bit 5: direction (0 = forward, 1 = backward) bit 4 headlights on/off (= DCC function F0) bit 3/2 DCC speed step system (see 4.6) bit 1 decel. time "BZ" (definable by command "B") on/off bit 0 accel. time "AZ" (definable by command "B") on/off
8	cData2	bit 0-7: function outputs 1-8 on/off (DCC only)
9	cData3	bit 0-3: function outputs 9-12 on/off (DCC only)

Reply: Ack (level 1) see also 4.7 and 4.9

invert function bits

header byte	value	description
1	0-255	unique sequence-ID
2	0x10	command station instruction
3	4	invert function bits
4	cAdr_hi	loco address high byte bit 6 + bit 7 format specifications (see 4.5)
5	cAdr_lo	loco address low byte
6	cData1	the following bits are toggled when set: bit 7: MAN (override signal controlled speed limit) bit 6: no function bit 5: direction (0 = forward, 1 = reverse) bit 4 headlights on/off (= DCC function F0) bit 1 decel. time "BZ" (definable by command "B") on/off bit 0 accel. time "AZ" (definable by command "B") on/off
7	cData2	bit 0-7: function outputs 1-8 on/off (DCC only)
8	cData3	bit 0-3: function outputs 9-12 on/off (DCC only)

Reply: Ack (level 1) see also 4.7 and 4.9

acceleration / deceleration (AZ / BZ) command

header byte	value	description
1	0-255	unique sequence-ID
2	0x10	command station instruction
3	5	acceleration / deceleration command
4	cAdr_hi	loco address high byte bit 6 + bit 7 format specifications (see 4.5)
5	cAdr_lo	loco address low byte
6	cAzBz	bit 0-3: BZ (0 - 15) bit 4-7: AZ (0 - 15)

Reply: Ack (level 1) see also 4.7 and 4.9

shuttle train command

header byte	value	description
1	0-255	unique sequence-ID
2	0x10	command station instruction
3	6	shuttle train command
4	cAdr_hi	loco address high byte bit 6 + bit 7 format specifications (see 4.5)
5	cAdr_lo	loco address low byte
6	cData	bit 0-3: contact rails 1-4 forward bit 4-7: contact rails 1-4 reverse

Reply: Ack (level 1) see also 4.7 and 4.9

accessory decoder command

header byte	value	description
1	0-255	unique sequence-ID
2	0x10	command station instruction
3	7	accessory decoder command
4	cAdr_hi	accessory address high byte bit 6 + bit 7 format specifications (see 4.5)
5	cAdr_lo	accessory address low byte
6	cData	bit 3: switching output on / off (1=on, 0=off) bit 2-0: number of output that should be activated

Reply: Ack (level 1) see also 4.7 and 4.10

query command station's loco memory

header byte	value	description
1	0-255	unique sequence-ID
2	0x10	command station instruction
3	8	query command station's loco memory
4	cAdr_hi	address high byte bit 6 + bit 7 format specifications (see 4.5)
5	cAdr_lo	address low byte

Reply: Ack (level 1) see also 4.7 and 4.11

query command station's accessory decoder memory

header byte	value	description
1	0-255	unique sequence-ID
2	0x10	command station instruction
3	9	query command station's accessory decoder memory
4	cAdr_hi	address high byte bit 6 + bit 7 format specifications (see 4.5)
5	cAdr_lo	address low byte

Reply: Ack (level 1) see also 4.7 and 4.12

address control

header byte	value	description
1	0-255	unique sequence-ID
2	0x10	command station instruction
3	10	address control
4	cAdr_hi	address high byte bit 6 + bit 7 format specifications (see 4.5)
5	cAdr_lo	address low byte
6	cControl	bits 7: 0 – address status query 1 – set address status according to bits 1-0 bit 5: 1: accessory address 0: loco address bit 1: lock address when bit is set (no external changes) bit 0: log external changes when bit is set
7	cOutputs	optional: for accessory decoder addresses: the outputs that shall be locked may be defined – keep in mind that there need to be 2 bits set for each paired output, if zero locking is deactivated

Reply: Ack (level 1) see also 4.7 and 4.13

read command station I/O state

header byte	value	description
1	0-255	unique sequence-ID
2	0x10	command station instruction

3	11	read command station
4	0	command station

Reply: Ack (level 1) see also 4.7 and 4.14

read/set a command station CV

header byte	value	description
1	0-255	unique sequence-ID
2	0x10	command station instruction
3	12	read/set a command station CV
4	variable_hi	configuration variable number high byte that shall be read/set
5	variable_lo	configuration variable number low byte that shall be read/set
6	value	optional: if a value is present it will be set as new CV-value

Reply: Ack (level 1)) see also 4.7 and 4.15

command station equipment query

header byte	value	description
1	0-255	unique sequence-ID
2	0x10	command station instruction
3	13	command station equipment query
4	0	command station

Reply: Ack (level 1) see also 4.7 and 4.16

serial info

This command allows simple identification of the software connected to the command station. Furthermore it provides a way to inform the command station that the communication is about to stop and thus avoid a false broken connection error message.

header byte	value	description
1	0-255	unique sequence-ID
2	0x10	command station instruction
3	17	info from service tool
4	ToolID	0 = default value (no start command necessary) 1 = ZST (Zimo Service Tool) 2 = FTC (Freiwald Train Controller) 3 = KAM (KAM Train Server) (Version 5)

Version5

Revision4

		4 = ADA (Sperrer ADaPT) (Version 5) 5 = STP (Sperrer STP) (Version 5) 6 = ZIR (ZIRC) (Version 5)
5	Action	0 communication end 1 communication start 2 communication timeout-refresh

Reply: Ack (level 1)

read/set a decoder CV (Version 5)

At this time the command station supports only CV read/set commands for DCC decoder addresses. If the given decoder address is 0 register programming on the programming track is performed, otherwise on the main programming is used

header byte	value	Description
1	0-255	unique sequence-ID
2	0x10	command station instruction
3	19	read/set a decoder CV
4	cAdr_hi	address high byte bit 6 + bit 7 format specifications (see 4.5)
5	cAdr_lo	address low byte
6	variable_hi	configuration variable number high byte that shall be read/set
7	variable_lo	configuration variable number low byte that shall be read/set
8	value	optional: if a value is present it will be set as new CV-value

Reply: Ack (level 1) see also 4.7 and 4.17

current loco memory

If logging is activated for a loco address, this message is sent spontaneously whenever loco memory's state changes due to external input.

header byte	value	description
1	0-255	unique sequence-ID
2	0x00	command station message
3	255	current loco memory
4	cAdr_hi	address high byte bit 6 + bit 7 format specification (see 4.5)
5	cAdr_lo	address low byte
6	cSpeed	speed step of the current speed step system

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		(DCC data signal: 0-14, 0-28 or 0-126; according to bit 3/2 in cData1;MOTOROLA protocol: 0-14)
7	cData1	bit 7: MAN (override signal controlled speed limit) bit 6: no function bit 5: direction (0 = forward, 1 = reverse) bit 4 headlights on/off (= DCC function F0) bit 3/2 DCC speed step system (see 4.6) bit 1 decel. time "BZ" (definable by command "B") on/off bit 0 accel. time "AZ" (definable by command "B") on/off
8	cData2	bit 0-7: function outputs 1-8 on/off (DCC only)
9	cData3	bit 0-3: function outputs 9-12 on/off (DCC only)
10	cAzBz	bit 0-3: BZ (0 - 15) bit 4-7: AZ (0 - 15)
11	cStatus	1 ... address is active

Reply: Ack (level 1)

current accessory decoder memory

If logging is activated for an accessory decoder address, this message is sent spontaneously whenever accessory decoder memory's state changes due to external input.

header byte	value	description
1	0-255	unique sequence-ID
2	0x00	command station message
3	254	current accessory decoder memory
5	cAdr_hi	address high byte bit 6 + bit 7 format specification (see 4.5)
6	cAdr_lo	address low byte
7	cPair	0 ... paired output function 1 ... single output function
8	cOutputs	state of the 8 outputs

Reply: Ack (level 1)

accessory module messages (MX8)

activate/deactivate spontaneous messages of an accessory module

header byte	value	description
1	0-255	unique sequence-ID
2	0x11	MX8 control instruction
3	0	activate / deactivate spontaneous messages
4	MX8_ID	MX8 address (0-63 not 800-863)
5	Output0	The bits 0-7 represent the module outputs 0-7
6	Output1	The bits 0-7 represent the module outputs 8-15.
7	Output2	The bits 0-7 represent the module outputs 16-23
8	Output3	The bits 0-7 represent the module outputs 24-31. The message forwarding is activated for all main sections if the corresponding bit is set, otherwise it is deactivated. The odd bits of paired outputs are meaningless.

Reply: Ack (level 1)

activate selected spontaneous messages of an accessory module

header byte	value	description
1	0-255	unique sequence-ID
2	0x11	MX8 control instruction
3	1	activate additional spontaneous messages
4	MX8_ID	MX8 address (0-63 not 800-863)
5	Output0	The bits 0-7 represent the module outputs 0-7
6	Output1	The bits 0-7 represent the module outputs 8-15.
7	Output2	The bits 0-7 represent the module outputs 16-23
8	Output3	The bits 0-7 represent the module outputs 24-31. The message forwarding is activated for all main sections with their corresponding bit set, for all others the forwarding remains unchanged. The odd bits of paired outputs are meaningless.

Reply: Ack (level 1)

deactivate selected spontaneous messages of an accessory module

header byte	value	description
1	0-255	unique sequence-ID
2	0x11	MX8 control instruction
3	2	deactivate additional spontaneous messages
4	MX8_ID	MX8 address (0-63 not 800-863)
5	Output0	The bits 0-7 represent the module outputs 0-7
6	Output1	The bits 0-7 represent the module outputs 8-15.
7	Output2	The bits 0-7 represent the module outputs 16-23
8	Output3	The bits 0-7 represent the module outputs 24-31. The message forwarding is deactivated for all main sections with their corresponding bit set, for all others the forwarding remains unchanged. The odd bits of paired outputs are meaningless.

Reply: Ack (level 1)

set output of accessory module

header byte	value	description
1	0-255	unique sequence-ID
2	0x11	MX8 control instruction
3	3	set output of accessory module
4	MX8_ID	MX8 address (0-63 not 800-863)
5	cData	bit 0-5: number of module output bit 6: position (0 = left, 1 = right) bit 7 is not used

Reply: Ack (level 1)

query accessory module outputs

header byte	value	Description
1	0-255	unique sequence-ID
2	0x11	MX8 control instruction
3	4	query accessory module outputs
4	MX8_ID	MX8 address (0-63 not 800-863)

Reply: Ack (level 1), Ack (level 2) see also 4.18

read/set a MX8-CV

header byte	value	Description
1	0-255	unique sequence-ID
2	0x11	MX8 control instruction
3	5	read/set a MX8-CV
4	MX8_ID	MX8 address (0-63 not 800-863)
5	variable_hi	configuration variable number high byte that shall be read/set
6	variable_lo	configuration variable number low byte that shall be read/set
7	value	optional: if a value is present it will be set as new CV-value

Reply: Ack (level 1), Ack (level 2) see also 4.19

current accessory module output state

If spontaneous messages are activated for an accessory module's output, this message is sent spontaneously whenever it's state changes.

header byte	value	description
1	0-255	unique sequence-ID
2	0x01	MX8 message
3	255	current accessory module output state
4	MX8_ID	MX8 address (0-63 not 800-863)
5	cData	bit 0-5: module output number bit 6: position (0 = left, 1 = right) bit 7 paired output
6	cCommand	0 state detected by MX8 (feedback) 1 new state sent to MX8

Reply: Ack (level 1)

track section module messages (MX9)

It is possible to choose individual MX9 track sections for forwarding spontaneous status messages (occupancy and loco numbers) as well as to query the current state of the module's track sections.

activate/deactivate spontaneous messages of a track section module

header byte	value	description
1	0-255	unique sequence-ID
2	0x12	MX9 control instruction
3	0	activate / deactivate spontaneous messages

4	MX9_ID	MX9 address (0-63 not 900-963)
5	sections	The bits 0-7 represent the main sections 0-7. The message forwarding is activated for all main sections if the corresponding bit is set, otherwise it is deactivated.

Reply: Ack (level 1)

activate selected spontaneous messages of a track section module

header byte	value	description
1	0-255	unique sequence-ID
2	0x12	MX9 control instruction
3	1	activate additional spontaneous messages
4	MX9_ID	MX9 address (0-63 not 900-963)
5	sections	The bits 0-7 represent the main sections 0-7. The message forwarding is activated for all main sections with their corresponding bit set, for all others the forwarding remains unchanged.

Reply: Ack (level 1)

deactivate selected spontaneous messages of a track section module

header byte	value	description
1	0-255	unique sequence-ID
2	0x12	MX9 control instruction
3	2	deactivate additional spontaneous messages
4	MX9_ID	MX9 address (0-63 not 900-963)
5	sections	The bits 0-7 represent the main sections 0-7. The message forwarding is deactivated for all main sections with their corresponding bit set, for all others the forwarding remains unchanged.

Reply: Ack (level 1)

read the track section module's occupancy state

header byte	value	description
1	0-255	unique sequence-ID
2	0x12	MX9 control instruction
3	3	read the track section module's occupancy state
4	MX9_ID	MX9 address (0-63 not 900-963)

Reply: Ack (level 1)) see also 4.20

read the track occupancy state and loco numbers of a main section

header byte	value	description
1	0-255	unique sequence-ID
2	0x12	MX9 control instruction
3	4	read the occupancy state and loco numbers of the section
4	MX9_ID	MX9 address (0-63 not 900-963)
5	section	main section number

Reply: Ack (level 1) see also 4.21

set new speed limits of a main track section

header byte	value	description
1	0-255	unique sequence-ID
2	0x12	MX9 control instruction
3	5	set new speed limits to the section
4	MX9_ID	MX9 address (0-63 not 900-963)
5	section	main section number
6	Limit	speed limit (H=0, U=1, L=2, F=3, A=4, HU=5, UL=6, LF=7)
7	Limit2	optional: apply speed limit when reaching section A (bit 7=1) or section B (bit 7=0); there is no speed limit change when reaching the second section if this value is omitted

Reply: Ack (level 1)

set LED-outputs of a track section module

header byte	value	description
1	0-255	unique sequence-ID
2	0x12	MX9 control instruction
3	6	set LED-outputs
4	MX9_ID	MX9 address (0-63 not 900-963)
5	cGreen	settings for „green-LED's“ on connector “signals”
6	cRed	settings for „red-LED's“ on connector “signals”
7	cLedsA	optional: settings for „LED's-A“ on connector “occupancy indicators”

8	cLedsB	settings for „LED's-B" on connector "occupancy indicators" Attention: after sending a message including the optional settings for the leds on connector "occupancy indicators", these outputs are no longer controlled automatically by the MX9 and do not represent the occupancy status!
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Reply: Ack (level 1)

read/set a MX9-CV

header byte	value	description
1	0-255	unique sequence-ID
2	0x12	MX9 control instruction
3	7	read/set a MX9-CV
4	MX9_ID	MX9 address (0-63 not 900-963)
5	variable	configuration variable that shall be read/set
6	value	optional: if a value is present it will be set as new CV-value

Reply: Ack (level 1), Ack (level 2) see also 4.22

main track section message

If spontaneous messages are activated for a track section module's section, this message is sent spontaneously whenever it's state changes.

header byte	value	description
1	0-255	unique sequence-ID
2	0x02	MX9 message
3	255	main section status
4	MX9_ID	MX9 address (0-63 not 900-963)
5	Section	main section number (0-7)
6	B-Status	occupancy state of main section 0 V C S B A T T T V: data valid C: changed (since last transmission) S: short circuit (main section off) B: section B occupied A: section A occupied T T T: number of recognized loco numbers (0-4)
7	F-Status	current speed limit (H=0, U=1, L=2, F=3, A=4, HU=5, UL=6, LF=7)
8	Zugnr1_H	optional: 1. loco number high byte
9	ZugNr1_L	optional: 1. loco number low byte
10	ZugNr2_H	optional: 2. loco number high byte

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11	ZugNr2_L	optional: 2. loco number low byte
12	ZugNr3_H	optional: 3. loco number high byte
13	ZugNr3_L	optional: 3. loco number low byte
14	ZugNr4_H	optional: 4. loco number high byte
15	ZugNr4_L	optional: 4. loco number low byte

Reply: Ack (level 1)

3.1.2. long frame protocol messages

general messages

acknowledge/reply sent by command station (level 1)

header byte	value	description
1	0-255	unique sequence-id
2	1100xxxx	acknowledgement/reply sent by command station (level 1)
3	XXX	same as primary message
4	dd00nnnn	nnnn ... length of header dd ... additional data flow information (see 4.8)
5	ID	sequence-id of the message that is being acknowledged

Reply: n.a.

acknowledge/reply sent by PC (level 1)

header byte	value	description
1	0-255	unique sequence-id
2	1101xxxx	acknowledgement/reply sent by PC (level 1)
3	XXX	same as primary message
4	dd00nnnn	nnnn ... length of header dd ... additional data flow information (see 4.8)
5	ID	sequence-id of the message that is being acknowledged

Reply: n.a.

acknowledge/reply sent by MX1 (level 2)

header byte	value	description
1	0-255	unique sequence-id

2	1010xxxx	acknowledgement/reply sent by command station (level 2)
3	XXX	same as primary message
4	dd00nnnn	nnnn ... length of header dd ... additional data flow information (see 4.8)
5	ID	sequence-id of the message that is being acknowledged

Reply: Ack (level 1)

acknowledge/reply sent by PC (level 2)

header byte	value	description
1	0-255	unique sequence-id
2	1011xxxx	acknowledgement/reply sent by PC (level 2)
3	XXX	same as primary message
4	dd00nnnn	nnnn ... length of header dd ... additional data flow information (see 4.8)
5	ID	sequence-id of the message that is being acknowledged

Reply: Ack (level 1)

display control of command station

The characters that will be displayed are the data bytes following the header bytes and the command station stops to update the display. If there are no characters following the header data the display returns to normal.

header byte	value	description
1	0-255	unique sequence-id
2	0x90	command station instruction
3	18	display control of command station
4	5	length of header (5), no more frames
5	index	position of the 1. character (0-31)

Reply: Ack (level 1)

3.2. checksum

The checksum includes all bytes of the original raw data of the data frame (i.e. header info and data) but excluding the protecting escape characters and without XOR'ing with 0x20.

3.2.1. checksum8

Checksum8 is an 8 bit checksum as it is utilized by various chip manufacturers (with the polynomial $x^8 + x^5 + x^4 + 1$, bit reversion for data and remainder, initialized with 0xff)

3.2.2. checksum16

Checksum16 is a 16 bit checksum (CRC16/CITT: with the polynomial $x^{16} + x^{12} + x^5 + 1$, initialized with 0xffff). The high byte of the checksum is written first (big endian).

4. Protocol details

Each message has a unique sequence-ID. After sending the final EOT, an acknowledgment or reply is expected for a specific length of time. If no such acknowledgment or reply is received, the message will be sent again with the same sequence-ID. If the reply is a negative acknowledgement, the message is resent immediately. If a message with the same sequence-ID is received the appropriate reply will be re-sent, as the original reply was obviously lost – any additional actions will be omitted as they were fulfilled when the message was correctly received the first time. There are some rare cases of messages that are never to be acknowledged – for example the confirmation messages themselves (ACK,NAK).

In order to prevent the possibility of incorrect communication due to hardware related faults the confirmation messages of the command station and PC are different.

4.1. reset message

The reset message provides a synchronization of the sending and receiving station's (either one may be a PC or command station). After a reset, all buffers are cleared and the sequence ID's are reset. If the special acknowledgement for a reset message is received by the sender, everything is ok. If there is no reply or a negative acknowledgement the reset message has to be sent again just as any "normal" message would have to be too. In the rare case of a sequence ID conflict (the newly received reset message has the same sequence ID as the last (non reset) message) the answer would be a "normal" acknowledgement for the previous message. In this case the reset message has to be re-sent with the next sequence ID and thus resolve the conflict.

If the command station initiates a (spontaneous) reset of the serial communication, it will send a reset message.

4.2. negative acknowledgement

If a corrupt message is received, that is a message that fails the checksum test, a negative acknowledgement is sent. As it is impossible in these cases to determine whether the received sequence-ID of the incoming frame is correct, it has to be assumed as incorrect. Therefore a negative acknowledgement message cannot contain the sequence-ID of the message it's referring to – the sender must determine the erroneous message.

4.3. acknowledgement / reply - level 1

When a data frame is correctly received it is acknowledged with its unique sequence-ID. Additionally requested data may be included in the reply if it's immediately available in the command station –

data not available at this time will be sent separate via acknowledge/reply level 2. Alternatively, there may be a return code or data included to describe the result of the request.

4.4. acknowledgement / reply - level 2

A level 2 confirmation message is basically a normal message (including a reference to the primary message) that has to be acknowledged by the receiver.

4.5. address format specification

For messages:

bit 7	bit 6	description
0	0	use protocol last used with this address
1	0	force DDC protocol
0	1	force Motorola protocol
1	1	reserved

For replies:

bit 7	bit 6	description
0	0	not used
1	0	address uses DDC protocol
0	1	address uses Motorola protocol
1	1	reserved

For decoder CV access via register programming: (Version 5)

bit 7	bit 6	description
0	0	not used
1	0	address uses DDC protocol
0	1	address uses Motorola protocol
1	1	Reserved

For decoder CV access via on-the-main programming: (Version 5)

bit 7	bit 6	description
0	0	Reserved
0	1	Reserved
1	0	decoder address uses DDC protocol
1	1	accessory decoder address uses DDC protocol

4.6. speed step system

The speed system bits are only meaningful for loco addresses using the DCC protocol.

For messages:

bit 3	bit 2	description
0	0	use speed system last used with this address
0	1	force 14 speed steps (0-14)
1	0	force 28 speed steps (0-28)
1	1	force 126 speed steps (0-126)

For replies:

bit 3	bit 2	Description
0	0	not used
0	1	address uses 14 speed steps (0-14)
1	0	address uses 28 speed steps (0-28)
1	1	address uses 126 speed steps (0-126)

4.7. additional return code to a message

The reply to message 0x0A inherits an additional return code. This return code reflects the logical error-status of the sent message. If the message is transmitted correctly but there is a logical error within the message that prevents the command station from executing it, then the codes below indicate the reason for it.

Return code	value	description
NO_ERROR	0x00	no error within the request
ERR_ADRESSE	0x01	not a valid address
ERR_INDEX	0x02	error with index of extended address
ERR_FORWARD	0x03	request couldn't be forwarded
ERR_BUSY	0x04	the command station is busy with an other accessory decoder command
ERR_NO_MOT	0x05	Motorola jumper off
ERR_NO_DCC	0x06	DCC jumper off
ERR_CV_ADRESSE	0x07	not a valid CV address
ERR_SECTION	0x08	not a valid section
ERR_NO_MODUL	0x09	module with given address doesn't exit
ERR_MESSAGE	0x0a	error within message
ERR_SPEED	0x0b	given speed not valid (Version 5)

4.8. additional data flow information

The fourth header byte of long data frames contains, besides the length of the header (original length without counting escape character prefixes), additional data flow information. This information describes whether there will be any consecutive frames with data.

flow information in dd	description
00	no more data to come
01	more data will follow
10	more data will possibly follow

4.9. reply to message 0x10, codes 3, 4, 5, 6

In case there is no error within a request, the level 1 acknowledgement contains additional information. If the track state is not in normal operational mode bit 0 is set. In this case the actual track state can be determined via the track control message.

header byte	value	description
1	0-255	unique sequence-ID
2	0x40	reply level 1 – short frame
3	3,4,5,6	code of message being replied to
4	ID	sequence-ID of the message being replied to
5	0	no error within the request
6	ff00ss0t	ff used format specification (see 4.5) ss used speed step system (see 4.6) t track state (0: normal operation, 1: fault)

4.10. reply to message 0x10, code 7

In case there is no error within the request, the level 1 acknowledgement contains additional information. If the track state is not in normal operational mode, bit 0 is set. In this case the actual track state can be determined via the track control message.

header byte	value	description
1	0-255	unique sequence-ID
2	0x40	reply level 1 – short frame
3	7	code of message being replied to
4	ID	sequence-ID of the message being replied to
5	0	no error within the request
6	ff00000t	ff used format specification (see 4.5) t track state (0: normal mode, 1: fault)

4.11. reply to message 0x10, code 8 (query command station's loco memory)

In case there is no error within the request, the level 1 acknowledgement contains the requested data.

header byte	value	description
1	0-255	unique sequence-ID
2	0x40	reply level 1 – short frame
3	8	code of message being replied to
4	ID	sequence-ID of the message being replied to
5	0	no error within the request
6	cAdr_hi	address high byte bit 6 + bit 7 format specification (see 4.5)
7	cAdr_lo	address low byte
8	cSpeed	speed step of the current speed step system (DCC data signal: 0-14, 0-28 or 0-126; according to bit 3/2 in cData1; MOTOROLA protocol: 0-14)
9	cData1	bit 7: MAN (override signal controlled speed limit) bit 6: no function bit 5: direction (0 = forward, 1 = reverse) bit 4: headlights on/off (= DCC function F0) bit 3/2: DCC speed step system (see 4.6) bit 1: decel. time "BZ" (definable by command "B") on/off bit 0: accel. time "AZ" (definable by command "B") on/off
10	cData2	bit 0-7: function outputs 1-8 on/off (DCC only)
11	cData3	bit 0-3: function outputs 9-12 on/off (DCC only)
12	cAzBz	bit 0-3: BZ (0 - 15) bit 4-7: AZ (0 - 15)
13	cStatus	1 ... address is active

**4.12. reply to message 0x10, code 9
(query command station's accessory decoder memory)**

In case there is no error within the request, the level 1 acknowledgement contains the requested data.

header byte	value	description
1	0-255	unique sequence-ID
2	0x40	reply level 1 – short frame
3	9	code of message being replied to
4	ID	sequence-ID of the message being replied to
5	0	no error within the request
6	cAdr_hi	address high byte bit 6 + bit 7 format specification (see 4.5)
7	cAdr_lo	address low byte
8	cPair	0 ... paired output function 1 ... single output function
9	cOutputs	state of the 8 outputs

4.13. reply to message 0x10, code 10 (address control)

header byte	value	description
1	0-255	unique sequence-ID
2	0x40	reply level 1 – short frame
3	10	code of message being replied to
4	ID	sequence-ID of the message being replied to
5	0	no error within the request
6	ffa0sskl	ff used format specification (see 4.5) a 1: accessory address 0: loco address ss used speed step system (see 4.6) k lock address if bit is set (no external changes) l log external changes if bit is set
7	cOutputs	bit mask of locked outputs of accessory address (only included if applicable)

4.14. reply to message 0x10, code 11 (read command station I/O state)

Voltage values are given in 0.1 V. Current values are given in 0.01 A.

header byte	value	Description
1	0-255	unique sequence-ID
2	0x40	reply level 1 – short frame
3	11	code of message being replied to
4	ID	sequence-ID of the message being replied to
5	0	values for command station
6	cCurrent1_h	current output 1 - high byte
7	cCurrent1_l	current output 1 – low byte [0.01A]
8	cVoltage1	voltage output 1 – [0.1V]
9	cCurrent2_h	current output 2 – high byte (0 for MX1_EC)
10	cCurrent2_l	current output 2 - low byte [0.01A] (0 for MX1_EC)
11	cVoltage2	voltage output 2 - [0.1V] (0 for MX1_EC)
12	cAux	auxiliary inputs

Current values with bit 15 set are special values:

special value	decription
0x8000	no 2 nd value (MX1EC)
0x8001	“OFF”
0x8002	“UEP”
0x8003	“UES”
0x8004	“AUS”
0x8005	“SSP”
0x8006	“No SI”
0x8007	“SL UES”

4.15. reply to message 0x10, code 12 (read/set a CV of the command station)

header byte	value	description
1	0-255	unique sequence-ID
2	0x40	reply level 1 – short frame
3	12	code of message being replied to
4	ID	sequence-ID of the message being replied to
5	0	no error within the request
6	cValue	value of the CV

4.16. reply to message 0x10, code 13 (command station equipment query)

This is a long frame level 1 reply. The returned data (following the header bytes) includes the following information:

byte number	value	description
1	cAddress_h	unique (CAN-)address high byte
2	cAddress_l	unique (CAN-)address low byte
3	cDevice	device – ID
4	cRom_size	ROM size of command station [32k –pages]
5	cRam_size	RAM size of command station [32k –pages]
6	cPrintver_h	print version main number
7	cPrintver_l	print version sub-number
8	cVerison_h	sw-Version main number
9	cVersion_l	sw-Version sub-number
10	cDate_day	sw-date day
11	cDate_month	sw-date month
12	cDate_century	sw-date century
13	cDate_year	sw-date year
14	cSwitches	switches
15	cDevelopVersion	00 Release or ASCII-pre-release version („a“, „b“, ..)
16	cBootRom_h	boot rom version main number
17	cBootRom_l	boot rom version sub-number
18	cBootRom_develop	00 boot rom release or ASCII-pre-release version („a“, „b“, ..)
19	0	values for command station

meaning of the device-ID:

device – ID	device
1	MX1 2000 / HS
2	MX1 2000 EC
3	MX31 ZL

4.17. reply to message 0x10, code 19 (read/set a decoder CV) (Version 5)

In a first step, the usual level 1 acknowledgment follows. The received data is forwarded as a level 2 reply with short frames:

header byte	value	Description
1	0-255	unique sequence-ID
2	0x20	reply level 2 – short frame

3	19	code of message being replied to
4	ID	sequence-ID of the message being replied to
5	cAdr_hi	address high byte bit 6 + bit 7 format specification (see 4.5)
6	cAdr_lo	address low byte
7	variable_hi	configuration variable number high byte that shall be read/set
8	variable_lo	configuration variable number low byte that shall be read/set
9	cValue	value of the CV

Reply: Ack (level 1)

In cases where the command station receives no data from the specified decoder, the reply doesn't contain any data or there occurred some error

header byte	value	Description
1	0-255	unique sequence-ID
2	0x20	reply level 2 – short frame
3	19	code of message being replied to
4	ID	sequence-ID of the message being replied to
5	cAdr_hi	address high byte bit 6 + bit 7 format specification (see 4.5)
6	cAdr_lo	address low byte
7	cError	error code

Reply: Ack (level 1)

A new read/set command of a decoder CV cannot be started until the previous query is finished. In case of an unfinished query, a level 1 reply is shown. If the source of the active query is a read/set command of a decoder CV additional information referring to the active query is included.

header byte	value	description
1	0-255	unique sequence-ID
2	0x40	reply level 1 – short frame
3	19	code of message being replied to
4	ID	sequence-ID of the message being replied to
5	0x04	busy – there is already an active request
6	cAdr_hi	address high byte (that couldn't be handled) bit 6 + bit 7 format specification (see 4.5)
7	cAdr_lo	address low byte

8	variable_hi	configuration variable number high byte that can't be read/set
9	variable_lo	configuration variable number low byte that can't be read/set
10	ID	optional: unique sequence-ID of the message that requested the query
11	cAdr_hi	optional: address high byte (that is currently being serviced) bit 6 + bit 7 format specification (see 4.5)
12	cAdr_lo	optional: address low byte
13	variable_hi	optional: configuration variable number high byte that is read/set
14	variable_lo	optional: configuration variable number low byte that is read/set

Reply: n.a.

4.18. reply to message 0x11, code 4 (query accessory module outputs)

In a first step, the usual level 1 acknowledgment follows. The received data is forwarded as a level 2 reply with short frames. The data of the frame includes the following information:

header byte	value	description
1	0-255	unique sequence-ID
2	0x21	reply level 2 – short frame
3	4	code of message being replied to
4	ID	sequence-ID of the message that is being acknowledged
5	MX8_ID	MX8 address (0-63 not 800-863)
6	cTime0	pulse-time 0 (CV 515)
7	cTime1	pulse-time 1 (CV 516)
8	cTime2	pulse-time 2 (CV 517)
9	cTime3	pulse-time 3 (CV 518)
10	cPaired	number of paired outputs (0,8,16)
11	cOutput0	the bits 0-7 represent the module outputs 0-7
12	cOutput1	the bits 0-7 represent the module outputs 8-15.
13	cOutput2	the bits 0-7 represent the module outputs 16-23
14	cOutput3	the bits 0-7 represent the module outputs 24-31. For paired outputs (starting at output 0) the odd bits are meaningless.

Reply: Ack (level 1)

In cases where the command station receives no data from the specified accessory module or the reply doesn't contain any data

header byte	value	description
1	0-255	unique sequence-ID
2	0x21	reply level 2 – short frame
3	4	code of message being replied to
4	ID	sequence-ID of the message that is being acknowledged
5	MX8_ID	MX8 address (0-63 not 800-863)

Reply: Ack (level 1)

A new query of accessory module outputs cannot be started until the previous query is finished. In case there is an unfinished query, a level 1 reply is shown with additional information according to the active query.

header byte	value	description
1	0-255	unique sequence-ID
2	0x41	reply level 1 – short frame
3	4	code of message being replied to
4	ID	sequence-ID of the message being replied to
5	0x04	busy – there is already an active request
6	MX8_ID	MX8 address (0-63 not 800-863) that is blocked
7	ID	unique sequence-ID of the message that requested the query
8	MX8_ID	MX8 address (0-63 not 800-863) that is actually searched for

Reply: n.a.

4.19. reply to message 0x11, code 5 (read/set a MX8-CV)

In a first step, the usual level 1 acknowledgment follows. The received data is forwarded as a level 2 reply with short frames:

header byte	value	Description
1	0-255	unique sequence-ID
2	0x21	reply level 2 – short frame
3	5	code of message being replied to
4	ID	sequence-ID of the message being replied to
5	MX8_ID	MX8 address (0-63 not 800-863)
6	cValue	value of the CV

Reply: Ack (level 1)

In cases where the command station receives no data from the specified accessory module or the reply doesn't contain any data

header byte	value	Description
1	0-255	unique sequence-ID
2	0x21	reply level 2 – short frame
3	5	code of message being replied to
4	ID	sequence-ID of the message being replied to
5	MX8_ID	MX8 address (0-63 not 800-863)

Reply: Ack (level 1)

A new read/set a MX8-CV cannot be started until the previous query is finished. In case there is an unfinished query, a level 1 reply is shown with additional information according to the active query.

header byte	value	description
1	0-255	unique sequence-ID
2	0x41	reply level 1 – short frame
3	5	code of message being replied to
4	ID	sequence-ID of the message being replied to
5	0x04	busy – there is already an active request
6	MX8_ID	MX8 address (0-63 not 800-863)
7	ID	unique sequence-ID of the message that requested the query
8	MX8_ID	MX8 address (0-63 not 800-863) that is actually searched for

Reply: n.a.

4.20. reply to message 0x12, code 3 (read the track section module's occupancy state)

header byte	value	description
1	0-255	unique sequence-ID
2	0x42	reply level 1 – short frame
3	3	code of message being replied to
4	ID	sequence-ID of the message being replied to
5	0	No error within the request
6	MX9_ID	MX9 address (0-63 not 900-963)
7	B-Status0	occupancy state of main section 0 V C S B A T T T V: data valid C: changed (since last transmission) S: short circuit (main section off) B: section B occupied A: section A occupied T T T: number of recognized loco numbers (0-4)
8	B-Status1	occupancy state of main section 1
9	B-Status2	occupancy state of main section 2
10	B-Status3	occupancy state of main section 3
11	B-Status4	occupancy state of main section 4
12	B-Status5	occupancy state of main section 5
13	B-Status6	occupancy state of main section 6
14	B-Status7	occupancy state of main section 7

4.21. reply to message 0x12, code 4 (read the track occupancy state and loco numbers of a main section)

In case there was an error within the request, the error code will be sent within a short frame. If there was no error the requested data will be sent by a long frame as follows:

header byte	value	description
1	0-255	unique sequence-ID
2	0xC2	reply level 1 – long frame
3	4	code of message being replied to
4	5	length of header
5	ID	sequence-ID of the message being replied to
6	MX9_ID	MX9 address (0-63 not 900-963)
7	Section	main section number (0-7)
8	B-Status	occupancy state of main section 0 V C S B A T T T V: data valid

		C: changed (since last transmission) S: short circuit (main section off) B: section B occupied A: section A occupied T T T: number of recognized loco numbers (0-4)
9	F-Status	current speed limit (H=0, U=1, L=2, F=3, A=4, HU=5, UL=6, LF=7)
10	Zugnr1_H	optional: 1. loco number high byte
11	ZugNr1_L	optional: 1. loco number low byte
12	ZugNr2_H	optional: 2. loco number high byte
13	ZugNr2_L	optional: 2. loco number low byte
14	ZugNr3_H	optional: 3. loco number high byte
15	ZugNr3_L	optional: 3. loco number low byte
16	ZugNr4_H	optional: 4. loco number high byte
17	ZugNr4_L	optional: 4. loco number low byte

Reply: n.a.

4.22. reply to message 0x12, code 7 (read/set a MX9-CV)

In a first step, the usual level 1 acknowledgment follows. The received data is forwarded as a level 2 reply with short frames:

header byte	value	Description
1	0-255	unique sequence-ID
2	0x22	reply level 2 – short frame
3	7	code of message being replied to
4	ID	sequence-ID of the message being replied to
5	MX9_ID	MX9 address (0-63 not 900-963)
6	cValue	value of the CV

Reply: Ack (level 1)

In cases where the command station receives no data from the specified accessory module or the reply doesn't contain any data

header byte	value	Description
1	0-255	unique sequence-ID
2	0x22	reply level 2 – short frame
3	7	code of message being replied to
4	ID	sequence-ID of the message being replied to
5	MX9_ID	MX9 address (0-63 not 900-963)

Reply: Ack (level 1)

A new read/set a MX9-CV cannot be started until the previous query is finished. In case there is an unfinished query, a level 1 reply is shown with additional information according to the active query.

header byte	value	description
1	0-255	unique sequence-ID
2	0x42	reply level 1 – short frame
3	7	code of message being replied to
4	ID	sequence-ID of the message being replied to
5	0x04	busy – there is already an active request
6	MX9_ID	MX9 address (0-63 not 900-963)
7	ID	unique sequence-ID of the message that requested the query
8	MX9_ID	MX9 address (0-63 not 800-863) that is actually searched for