4 Driving

This chapter describes the messages that are required for driving with locomotive decoders.

A client can subscribe to locomotive infos with *4.1* LAN_X_GET_LOCO_INFO in order to be automatically informed about changes to this locomotive address caused also by other clients or handsets. Furthermore the corresponding broadcast must also be activated for the client, see ***2.16*** LAN_SET_BROADCASTFLAGS, Flag 0x00000001.

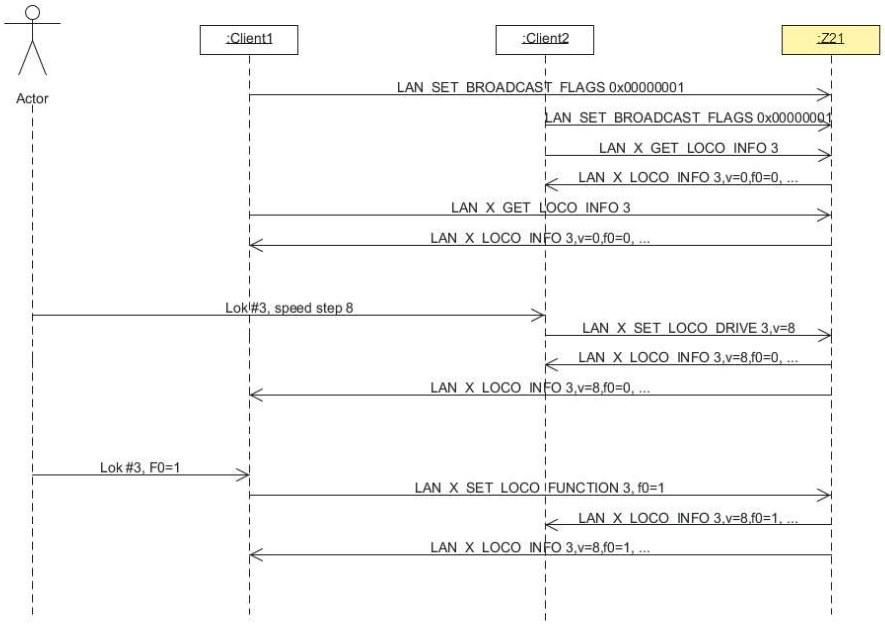

Figure 2 Example sequence: locomotive control

In order to keep network traffic within reasonable limits, a maximum of 16 locomotive addresses per client can be subscribed to (FIFO). You could also poll the locos, but always consider the network load: the IP packets may be deleted by the router in case of overload and UDP does not offer any detection mechanisms.

4.1 LAN_X_GET_LOCO_INFO

The following command can be used to poll the status of a locomotive. At the same time, the client also "subscribes" to the locomotive information for this locomotive address (only in combination with LAN_SET_BROADCASTFLAGS, Flag 0x00000001).

Request to Z21:

DataLen		**Header**		**Data**				
				X-Header	**DB0**	**DB1**	**DB2**	**XOR-Byte**
0x09	0x00	**0x40**	0x00	**0xE3**	**0xF0**	**Adr_MSB**	**Adr_LSB**	XOR-Byte

Note: loco address = (**Adr_MSB** & 0x3F) << 8 + **Adr_LSB**
For locomotive addresses ≥ 128, the two highest bits in DB1 must be set to 1:
DB1 = (**0xC0** | **Adr_MSB**). For locomotive addresses < 128, these two highest bits have no meaning.

Reply from Z21:
see *4.4* LAN_X_LOCO_INFO

4.2 LAN_X_SET_LOCO_DRIVE

Change the speed and direction of a locomotive.

Request to Z21:

DataLen		Header		Data					
				X-Header	DB0	DB1	DB2	DB3	XOR-Byte
0x0A	0x00	**0x40**	0x00	**0xE4**	**0x1S**	**Adr_MSB**	**Adr_LSB**	**RVVVVVVV**	XOR-Byte

Note: loco address = (**Adr_MSB** & 0x3F) << 8 + **Adr_LSB**
For locomotive addresses ≥ 128, the two highest bits in DB1 must be set to 1:
DB1 = (**0xC0** | **Adr_MSB**). For locomotive addresses < 128, these two highest bits have no meaning.

0x1**S** Number of speed steps, depending on the rail format set
S=0: DCC 14 speed steps, or MMI with 14 speed steps and F0
S=2: DCC 28 speed steps, or MMII with 14 real speed steps and F0-F4
S=3: DCC 128 speed steps (aka "126 speed steps" when not counting the stops), or MMII with 28 real speed steps (using light-trit) and F0-F4

RVVVVVVV R ... Direction: 1=forward
V ... Speed: depending on the speed steps S. Coding see below.
If the format MM is configured for the locomotive, the conversion of the given DCC speed stage into the real MM speed stage takes place automatically in the Z21.

The coding of the speed is similar to NMRA S 9.2 and S 9.2.1.
"**Stop**" means "normal stop" or "step 0". "**E-Stop**" means "immediate emergency stop".

Coding speed for "DCC 14":

R000 VVVV	Speed	R000 VVVV	Speed	R000 VVVV	Speed	R000 VVVV	Speed
R000 0000	**Stop**	R000 0100	Step 3	R000 1000	Step 7	R000 1100	Step 11
R000 0001	**E-Stop**	R000 0101	Step 4	R000 1001	Step 8	R000 1101	Step 12
R000 0010	Step 1	R000 0110	Step 5	R000 1010	Step 9	R000 1110	Step 13
R000 0011	Step 2	R000 0111	Step 6	R000 1011	Step 10	R000 1111	Step 14 **max**

Coding speed for "DCC 28" (like "DCC 14", but with additional intermediate speed step in the fifth bit V_5):

R00V_5 VVVV	Speed	R00V_5 VVVV	Speed	R00V_5 VVVV	Speed	R00V_5 VVVV	Speed
R000 0000	**Stop**	R000 0100	Step 5	R000 1000	Step 13	R000 1100	Step 21
R001 0000	**Stop**[1]	R001 0100	Step 6	R001 1000	Step 14	R001 1100	Step 22
R000 0001	**E-Stop**	R000 0101	Step 7	R000 1001	Step 15	R000 1101	Step 23
R001 0001	**E-Stop**[1]	R001 0101	Step 8	R001 1001	Step 16	R001 1101	Step 24
R000 0010	Step 1	R000 0110	Step 9	R000 1010	Step 17	R000 1110	Step 25
R001 0010	Step 2	R001 0110	Step 10	R001 1010	Step 18	R001 1110	Step 26
R000 0011	Step 3	R000 0111	Step 11	R000 1011	Step 19	R000 1111	Step 27
R001 0011	Step 4	R001 0111	Step 12	R001 1011	Step 20	R001 1111	Step 28 **max**

Coding speed for "DCC 128":

RVVV VVVV	Speed
R000 0000	**Stop**
R000 0001	**E-Stop**
R000 0010	Step 1
R000 0011	Step 2
R000 0100	Step 3
R000 0101	Step 4
…	…
R111 1110	Step 125
R111 1111	Step 126 **max**

[1] Usage not recommended

Reply from Z21:
No standard reply, *4.4* LAN_X_LOCO_INFO to subscribed clients.

Note: the number of speed steps (14/28/128) is automatically stored for the given loco address in the command station persistently.

4.3 Functions for locomotive decoder

Function commands from F0 up to and including F12 are sent periodically (priority dependent) on the main track, just like the speed and direction.

Function commands F13 and above, on the other hand, are sent three times on the main track after a change and then, regarding the available bandwidth on the track and according with RCN-212, are no longer sent until the next change of the function state.

4.3.1 LAN_X_SET_LOCO_FUNCTION

Change a function of a locomotive.

Request to Z21:

DataLen		**Header**		**Data**					
				X-Header	**DB0**	**DB1**	**DB2**	**DB3**	**XOR-Byte**
0x0A	0x00	**0x40**	0x00	**0xE4**	**0xF8**	**Adr_MSB**	**Adr_LSB**	**TTNN NNNN**	XOR-Byte

Note: loco address = (**Adr_MSB** & 0x3F) << 8 + **Adr_LSB**
For locomotive addresses ≥ 128, the two highest bits in DB1 must be set to 1:
DB1 = (**0xC0** | **Adr_MSB**). For locomotive addresses < 128, these two highest bits have no meaning.

TT switch type: 00=off, 01=on, 10=toggle,11=not allowed
NNNNNN Function index, 0x00=F0 (light), 0x01=F1 etc.

With Motorola MMI only F0 can be switched. With MMII, F0 to F4 can be used.
With DCC, F0 to F28 can be switched here. **From Z21 FW version 1.42** the extended range from **F0 to F31** can be used here.

Reply from Z21:
No standard reply, *4.4* LAN_X_LOCO_INFO to subscribed clients.

4.3.2 LAN_X_SET_LOCO_FUNCTION_GROUP

With the following command, a whole function group of a locomotive decoder can be switched. Thus, up to 8 functions can be switched with a single command. **From Z21 FW version 1.42**, DCC functions can be switched up to F31, and with some restrictions even up to F68.

The client should constantly monitor the status of all functions of the controlled locomotive to avoid accidentally switching off a function when sending this command, which may have been switched on before by another LAN client or handheld controller. For this reason, this command is more suitable for PC railroad automation software, because it should keep track of all vehicles anyway.

Request to Z21:

DataLen		Header		Data					
				X-Header	DB0	DB1	DB2	DB3	XOR-Byte
0x0A	0x00	**0x40**	0x00	**0xE4**	**Group**	**Adr_MSB**	**Adr_LSB**	**Functions**	XOR-Byte

Note: loco address = (**Adr_MSB** & 0x3F) << 8 + **Adr_LSB**
For locomotive addresses ≥ 128, the two highest bits in DB1 must be set to 1:
DB1 = (**0xC0** | **Adr_MSB**). For locomotive addresses < 128, these two highest bits have no meaning.

Groups and **functions** are structured as follows:

Number	Group	Functions								Remarks
	HEX	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
1	**0x20**	0	0	0	F0	F4	F3	F2	F1	(A)
2	**0x21**	0	0	0	0	F8	F7	F6	F5	
3	**0x22**	0	0	0	0	F12	F11	F10	F9	
4	**0x23**	F20	F19	F18	F17	F16	F15	F14	F13	(B)
5	**0x28**	F28	F27	F26	F25	F24	F23	F22	F21	(B)
6	**0x29**	F36	F35	F34	F33	F32	**F31**	**F30**	**F29**	**(C)** (D) (E)
7	**0x2A**	F44	F43	F42	F41	F40	F39	F38	F37	(D) (E)
8	**0x2B**	F52	F51	F50	F49	F48	F47	F46	F45	(D) (E)
9	**0x50**	F60	F59	F58	F57	F56	F55	F54	F53	(D) (E)
10	**0x51**	F68	F67	F66	F65	F64	F63	F62	F61	(D) (E)

Remarks:
(A) With Motorola MMI only F0 can be used, with MMII F0 up to F4 can be used.
(B) DCC F13 to F28 with this command only **from Z21 FW V1.24** and higher.
(C) DCC F29 to F31 **from Z21 FW V1.42**, including feedback to the LAN clients, see also below.
(D) DCC F32 to F68 **from Z21 FW V1.42**, however, there is no feedback to the LAN clients. The DCC function commands are only sent on the track.
(E) We cannot guarantee that the DCC function commands from F29 and higher will actually be understood by all decoders! Currently (2022) only very few DCC decoder types understand the function commands from F29 (F29 to F31 were tested successfully with "Loksound 5" decoder). Nowadays, some manufacturers also offer sound functions on F29, F30 or F31, but they often do not work with DCC in practice, because their multi-protocol decoders do not yet understand the corresponding new DCC commands.

Reply from Z21:
No standard reply, for function **F0 to F31** the feedback *4.4* LAN_X_LOCO_INFO is sent to subscribed clients.

4.3.3 LAN_X_SET_LOCO_BINARY_STATE

From Z21 FW Version 1.42, a DCC "Binary State" command can be sent to a locomotive decoder with the following command.

Request to Z21:

DataLen		Header		Data						
				X-Header	DB0	DB1	DB2	DB3	DB4	XOR-Byte
0x0A	0x00	**0x40**	0x00	**0xE5**	**0x5F**	**AH**	**AL**	**FLLL LLLL**	**HHHH HHHH**	XOR-Byte

Note: loco address = (**Adr_MSB** & 0x3F) << 8 + **Adr_LSB**
For locomotive addresses ≥ 128, the two highest bits in DB1 must be set to 1:
DB1 = (**0xC0** | **Adr_MSB**). For locomotive addresses < 128, these two highest bits have no meaning.

F The most significant bit **F** determines whether the binary state is on or off.
LLLLLLL The low-order **seven** (!) bits of the binary state address.
HHHHHHHH The high eight bits of the binary state address.

Note: The following applies: the 15-bit binary state address = (**HHHHHHHH** << **7**) + (**LLLLLLL** & 0x7F)

The binary states address range from 29 to 32767 is permitted.
Only binary state addresses ≥ 29 may be used for general switching functions.
The binary state addresses from 1 to 28 are reserved for special applications.
Binary state address 0 is reserved as broadcast.

Binary state addresses < 128 (i.e., if **HHHHHHHH** == 0) are **automatically** issued on the track as DCC "binary state control command **short form**" according to RCN-212, from ≥ 128 as DCC "binary state control command **long form**".

DCC binary state control commands are sent three times on the main track, and according to RCN-212, thereafter no more repeated regularly.

There is no response to the caller and no notification to other clients.

Reply from Z21:
None.

4.4 LAN_X_LOCO_INFO

This message is sent from the Z21 to the clients in response to the command *4.1* LAN_X_GET_LOCO_INFO. However, it is also unsolicitedly sent to an associated client if

- the locomotive status has been changed by one of the (other) clients or handset controls
- and the associated client has activated the corresponding broadcast, see ***2.16*** LAN_SET_BROADCASTFLAGS, Flag 0x00000001
- and the associated client has subscribed to the locomotive address with *4.1* LAN_X_GET_LOCO_INFO.

Z21 to Client:

DataLen		**Header**		**Data**									
				X-Header	**DB0**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**XOR-Byte**
7 + ***n***	0x00	**0x40**	0x00	0xEF	**Locomotive Information**								XOR-Byte

The actual packet length *n* may vary depending on the data actually sent, with ***7 ≤ n ≤ 14.***
From Z21 FW version 1.42 DataLen is ≥ 15 (**n ≥ 8**) for also transferring the status of F29, F30 and F31!

The data for locomotive information is structured as follows:

Position	**Data**	**Meaning**
DB0	**Adr_MSB**	The two highest bits in Adr_MSB must be ignored.
DB1	**Adr_LSB**	Loco address = (**Adr_MSB** & 0x3F) << 8 + **Adr_LSB**
DB2	0000**BKKK**	**M**=1 … **From Z21 FW version 1.43** identifies loco with MM output format **B**=1 ... the locomotive is controlled by another X-BUS handset controller ("busy") **KKK** ... Speed steps information: 0=14, 2=28, 4=128 0: DCC 14 speed steps, or MMI with 14 speed steps and F0 2: DCC 28 speed steps, or MMII with 14 real speed stages and F0-F4 **4**: DCC 128 speed steps, or MMII with 28 real speed stages (light-trit) and F0-F4
DB3	**RVVVVVVV**	**R** ... Directon: 1=forward **V** ... Speed. Coding also depends on the speed steps information KKK. See also above section *4.2* LAN_X_SET_LOCO_DRIVE. If the format MM is configured for the locomotive, then the conversion of the real MM speed step into the presented DCC speed step has already been done in the Z21.
DB4	0**DSLFGHJ**	**D** ... double traction: 1=Loco included in a double traction **S** ... Smartsearch **L** ... F0 (Licht) **F** ... F4 **G** ... F3 **H** ... F2 **J** ... F1
DB5	F5-F12	Function F5 is bit0 (LSB)
DB6	F13-F20	Function F13 is bit0 (LSB)
DB7	F21-F28	Function F21 is bit0 (LSB)
DB8	F29-F31	**From Z21 FW version 1.42** and if DataLen ≥ 15; Function F29 is bit0 (LSB)
DB***n***		optional, for future extensions

4.5 LAN_X_SET_LOCO_E_STOP

From Z21 FW version 1.43, a locomotive can be stopped with the following command. In the case of a DCC locomotive, the speed step "**E-STOP**" ("emergency stop" according to RCN-212) is then sent in the DCC speed command onto the track, i.e., the decoder should stop the engine as quickly as possible. In the case of an MM locomotive, the speed step 0 ("Stop") is sent onto the track.

Request to Z21:

DataLen		**Header**		**Data**			
				X-Header	**DB0**	**DB2**	**XOR-Byte**
0x08	0x00	**0x40**	0x00	**0x92**	**Adr_MSB**	**Adr_LSB**	XOR-Byte

Note: loco address = (**Adr_MSB** & 0x3F) << 8 + **Adr_LSB**
For locomotive addresses ≥ 128, the two highest bits in DB1 must be set to 1:
DB1 = (**0xC0** | **Adr_MSB**). For locomotive addresses < 128, these two highest bits have no meaning.

Reply from Z21:
No standard reply, *4.4* LAN_X_LOCO_INFO to subscribed clients.

4.6 LAN_X_PURGE_LOCO

From Z21 FW version 1.43, a locomotive can be removed from the Z21 with the following command. This also cancels the sending of the loco commands for this locomotive on the track. Sending will start again as soon as a new drive or function command is sent to the same locomotive address.

In this way, it is possible, for example, for a PC railroad automation software to influence the number of locomotives in the system and thus also the data throughput on the track.

Request to Z21:

DataLen		**Header**		**Data**				
				X-Header	**DB0**	**DB1**	**DB2**	**XOR-Byte**
0x09	0x00	**0x40**	0x00	**0xE3**	**0x44**	**Adr_MSB**	**Adr_LSB**	XOR-Byte

Note: loco address = (**Adr_MSB** & 0x3F) << 8 + **Adr_LSB**
For locomotive addresses ≥ 128, the two highest bits in DB1 must be set to 1:
DB1 = (**0xC0** | **Adr_MSB**). For locomotive addresses < 128, these two highest bits have no meaning.

There is no response to the caller and no notification to other clients.

Reply from Z21:
None.