

# **Z21 LAN Protocol Specification**

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# 1 Basics

## 1.1 Communication

Communication with the command station Z21 is done via UDP by using port 21105 or 21106. Control applications on the client (PC, App, ...) should primarily use port 21105.

Communication is always asynchronous, i.e. broadcast messages can occur between a request and the corresponding response.

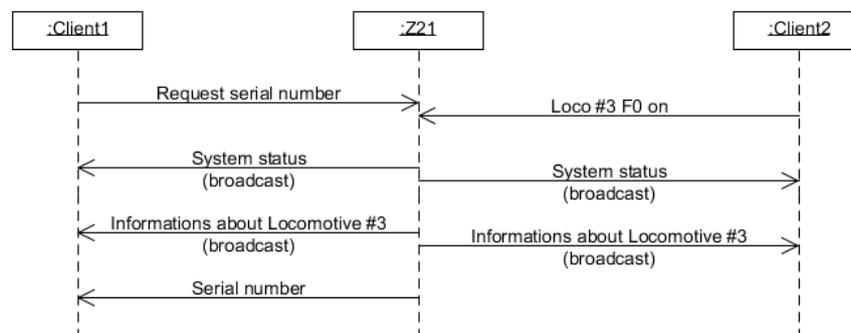


Figure 1 Example Sequence: Communication

Each client is expected to communicate with the Z21 once per minute, otherwise it will be removed from the list of active participants. If possible, a client should log off from the command station with the command LAN\_LOGOFF.

## 1.2 Z21 Dataset

### 1.2.1 Structure

A Z21 data record, i.e. a request or response, is structured in the following way:

DataLen (2 Byte)	Header (2 Byte)	Data (n Bytes)
------------------	-----------------	----------------

- **DataLen** (little endian):  
Total length over the entire data set including DataLen, Header and Data, i.e.  $DataLen = 2+2+n$ .
- **Header** (little endian):  
Describes the Command and the Protocol's group.
- **Data**:  
Structure and number depend on the command. For a detailed description, see the respective command.

Unless otherwise specified, the byte order is little-endian, i.e. first the low byte, then the high byte.

### 1.2.2 X-BUS Protocol tunneling

Requests and responses *based* on the X-BUS protocol are transmitted with the Z21-LAN-Header **0x40 (LAN\_X\_xxx)**. This only refers to the protocol, because these commands have nothing to do with the physical X-BUS of the Z21, but are exclusively addressed to the LAN clients or the Z21.

The actual X-BUS command is located inside the Data field within the Z21 data record. The last byte is a checksum and is calculated as XOR via the X-BUS command. Example:

DataLen		Header		Data			
0x08	0x00	0x40	0x00	X-Header	DB0	DB1	XOR-Byte
				h	x	y	h XOR x XOR y

### 1.2.3 LocoNet tunneling

#### From Z21 FW Version 1.20.

With the Z21-LAN headers 0xA0 and 0xA1 (LAN\_LOCONET\_Z21\_RX, LAN\_LOCONET\_Z21\_TX), messages received or sent by the Z21 on the LocoNet bus are forwarded to the LAN client. The LAN client can subscribe to these LocoNet messages by using the **2.16 LAN\_SET\_BROADCASTFLAGS**.

The LAN client can write messages to the LocoNet bus via the Z21-LAN header **0xA2 (LAN\_LOCONET\_FROM\_LAN)**.

This way the Z21 can be used as an Ethernet/LocoNet gateway, where the Z21 is also the LocoNet master managing the refresh slots and generating the DCC packets.

The actual LocoNet message is located inside the Data field within the Z21 data record.

Example Loconet message OPC\_MOVE\_SLOTS <0><0> („DISPATCH\_GET“) is sent by the Z21:

DataLen		Header		Data			
0x08	0x00	0xA0	0x00	OPC	ARG1	ARG2	CKSUM
				0xBA	0x00	0x00	0x45

More information about the LocoNet Gateway can be found in section **9 LocoNet**.

### 1.3 Combining datasets in one UDP packet

In the payload data of a UDP packet, several independent Z21 data sets can also be sent together to one recipient. Each recipient must be able to interpret these combined Z21 dataset packets.

#### Example

Following combined Z21 datasets in one UDP packet...

UDP Paket				
IP Header	UDP Header	UDP Payload		
		Z21 Dataset 1	Z21 Dataset 2	Z21 Dataset 3
		LAN_X_GET_TOURNOUT_INFO #4	LAN_X_GET_TOURNOUT_INFO #5	LAN_RMBUS_GETDATA #0

... is equivalent to these three UDP packets:

UDP Paket 1		
IP Header	UDP Header	UDP Payload
		Z21 dataset
		LAN_X_GET_TOURNOUT_INFO #4

UDP Paket 2		
IP Header	UDP Header	UDP Payload
		Z21 dataset
		LAN_X_GET_TOURNOUT_INFO #5

UDP Paket 3		
IP Header	UDP Header	UDP Payload
		Z21 dataset
		LAN_RMBUS_GETDATA #0

The UDP packet must fit into an Ethernet MTU, i.e. considering IPv4 header and UDP header there is a maximum of  $1500 - 20 - 8 = 1472$  bytes of payload data.

## 2 System, Status, Versions

### 2.1 LAN\_GET\_SERIAL\_NUMBER

Reading the serial number of the Z21.

Request to Z21:

DataLen		Header		Data
0x04	0x00	0x10	0x00	-

Reply from Z21:

DataLen		Header		Data
0x08	0x00	0x10	0x00	32 Bits Serial number (little endian)

### 2.2 LAN\_LOGOFF

Logging off the client from the Z21.

Request to Z21:

DataLen		Header		Data
0x04	0x00	0x30	0x00	-

Reply from Z21:

none

Use the same port number when logging out as when logging in.

**Note:** the login is implicitly done with the first command of the client (e.g. LAN\_SYSTEM\_STATE\_GETDATA, ...).

### 2.3 LAN\_X\_GET\_VERSION

The X-Bus version of the Z21 can be read out with the following command.

Request to Z21:

DataLen		Header		Data		
0x07	0x00	0x40	0x00	X-Header	DB0	XOR-Byte
				0x21	0x21	0x00

Reply from Z21:

DataLen		Header		Data				
0x09	0x00	0x40	0x00	X-Header	DB0	DB1	DB2	XOR-Byte
				0x63	0x21	0x30	0x12	0x60

DB1 ... X-Bus Version 3.0

DB2 ... command station ID, 0x12 = Z21

## 2.4 LAN\_X\_GET\_STATUS

This command can be used to request the Z21 status.

Request to Z21:

DataLen		Header		Data		
0x07	0x00	0x40	0x00	X-Header	DB0	XOR-Byte
				0x21	0x24	0x05

Reply from Z21:

see 2.12 LAN\_X\_STATUS\_CHANGED

This command station status is identical to the CentralState, which is delivered in the system status, see 2.18 LAN\_SYSTEMSTATE\_DATACHANGED.

## 2.5 LAN\_X\_SET\_TRACK\_POWER\_OFF

This command switches off the track voltage.

Request to Z21:

DataLen		Header		Data		
0x07	0x00	0x40	0x00	X-Header	DB0	XOR-Byte
				0x21	0x80	0xa1

Reply from Z21:

see 2.7 LAN\_X\_BC\_TRACK\_POWER\_OFF

## 2.6 LAN\_X\_SET\_TRACK\_POWER\_ON

This command switches on the track voltage, or terminates either the emergency stop or the programming mode.

Request to Z21:

DataLen		Header		Data		
0x07	0x00	0x40	0x00	X-Header	DB0	XOR-Byte
				0x21	0x81	0xa0

Reply from Z21:

see 2.8 LAN\_X\_BC\_TRACK\_POWER\_ON

## 2.7 LAN\_X\_BC\_TRACK\_POWER\_OFF

The following packet is sent from the Z21 to the registered clients when

- a client has sent command 2.5 LAN\_X\_SET\_TRACK\_POWER\_OFF.
- or the track voltage has been switched off by some input device (multiMaus).
- and the relevant client has activated the corresponding broadcast, see **2.16** LAN\_SET\_BROADCASTFLAGS, Flag 0x00000001

Z21 to Client:

DataLen		Header		Data		
0x07	0x00	0x40	0x00	X-Header	DB0	XOR-Byte
				0x61	0x00	0x61

## 2.8 LAN\_X\_BC\_TRACK\_POWER\_ON

The following packet is sent from the Z21 to the registered clients when

- a client has sent command 2.6 LAN\_X\_SET\_TRACK\_POWER\_ON.
- or the track voltage has been switched on by some input device (multiMaus).
- and the relevant client has activated the corresponding broadcast, see **2.16** LAN\_SET\_BROADCASTFLAGS, Flag 0x00000001

Z21 to Client:

DataLen		Header		Data		
0x07	0x00	0x40	0x00	X-Header	DB0	XOR-Byte
				0x61	0x01	0x60

## 2.9 LAN\_X\_BC\_PROGRAMMING\_MODE

The following packet is sent from the Z21 to the registered clients if the Z21 has been put into CV programming mode by **6.1** LAN\_X\_CV\_READ or **6.2** LAN\_X\_CV\_WRITE and the respective client has activated the corresponding broadcast, see

**2.16** LAN\_SET\_BROADCASTFLAGS, Flag 0x00000001

Z21 to Client:

DataLen		Header		Data		
0x07	0x00	0x40	0x00	X-Header	DB0	XOR-Byte
				0x61	0x02	0x63

## 2.10 LAN\_X\_BC\_TRACK\_SHORT\_CIRCUIT

The following packet is sent from the Z21 to the registered clients if a short circuit has occurred and the relevant client has activated the corresponding broadcast, see

**2.16** LAN\_SET\_BROADCASTFLAGS, Flag 0x00000001

Z21 to Client:

DataLen		Header		Data		
0x07	0x00	0x40	0x00	X-Header	DB0	XOR-Byte
				0x61	0x08	0x69

### 2.11 LAN\_X\_UNKNOWN\_COMMAND

The following packet is sent from the Z21 to the client in response to an invalid request.

Z21 to Client:

DataLen		Header		Data		
0x07	0x00	0x40	0x00	X-Header	DB0	XOR-Byte
				0x61	0x82	E3

### 2.12 LAN\_X\_STATUS\_CHANGED

The following packet is sent from the Z21 to the client if the client explicitly sets the status to 2.4 LAN\_X\_GET\_STATUS.

Z21 to Client:

DataLen		Header		Data			
0x08	0x00	0x40	0x00	X-Header	DB0	DB1	XOR-Byte
				0x62	0x22	Status	XOR-Byte

DB1 ... command station status

Bitmask for command station status:

```
#define csEmergencyStop      0x01 // The emergency stop is switched on
#define csTrackVoltageOff    0x02 // The track voltage is switched off.
#define csShortCircuit       0x04 // Short-circuit
#define csProgrammingModeActive 0x20 // The programming mode is active
```

This command station status is identical to the SystemState.CentralState, see 2.18 LAN\_SYSTEMSTATE\_DATACHANGED.

### 2.13 LAN\_X\_SET\_STOP

With this command the emergency stop is activated, i.e. the locomotives are stopped but the track voltage remains switched on.

Request to Z21:

DataLen		Header		Data	
0x06	0x00	0x40	0x00	X-Header	XOR-Byte
				0x80	0x80

Reply from Z21:

see 2.14 LAN\_X\_BC\_STOPPED

### 2.14 LAN\_X\_BC\_STOPPED

The following packet is sent from the Z21 to the registered clients when

- a client has sent command 2.13 LAN\_X\_SET\_STOP.
- or the emergency stop was triggered by some input device (multiMaus).
- and the relevant client has activated the corresponding broadcast, see 2.16 LAN\_SET\_BROADCASTFLAGS, Flag 0x00000001

Z21 to Client:

DataLen		Header		Data		
0x07	0x00	0x40	0x00	X-Header	DB0	XOR-Byte
				0x81	0x00	0x81

### 2.15 LAN\_X\_GET\_FIRMWARE\_VERSION

The firmware version of the Z21 can be read with this command.

Request to Z21:

DataLen		Header		Data		
0x07	0x00	0x40	0x00	X-Header	DB0	XOR-Byte
				0xF1	0x0A	0xFB

Reply from Z21:

DataLen		Header		Data				
0x09	0x00	0x40	0x00	X-Header	DB0	DB1	DB2	XOR-Byte
				0xF3	0x0A	V_MSB	V_LSB	XOR-Byte

**DB1** ... MSB of the Firmware version

**DB2** ... LSB of the Firmware version

The version is specified in BCD format.

**Example:**

0x09 0x00 0x40 0x00 0xf3 0x0a **0x01 0x23** 0xdb ... means: „Firmware Version 1.23“

## 2.16 LAN\_SET\_BROADCASTFLAGS

Set the broadcast flags in the Z21. These flags are set per client (i.e. per IP + port number) and must be set again the next time you log on.

Request to Z21:

Data	Len	Header	Data
0x08	0x00	0x50	0x00
32 Bits Broadcast-Flags (little endian)			

Broadcast flags are an OR-combination of the following values:

- 0x00000001 Broadcasts and info messages concerning driving and switching are delivered to the registered clients automatically.  
The following messages are concerned:  
  - 2.7 LAN\_X\_BC\_TRACK\_POWER\_OFF
  - 2.8 LAN\_X\_BC\_TRACK\_POWER\_ON
  - 2.9 LAN\_X\_BC\_PROGRAMMING\_MODE
  - 2.10 LAN\_X\_BC\_TRACK\_SHORT\_CIRCUIT
  - 2.14 LAN\_X\_BC\_STOPPED
  - 4.4 LAN\_X\_LOCO\_INFO (loco address must be subscribed too)
  - 5.3 LAN\_X\_TURNOUT\_INFO
- 0x00000002 Changes of the feedback devices on the R-Bus are sent automatically.  
Z21 Broadcast messages see 7.1 LAN\_RMBUS\_DATACHANGED
- 0x00000004 Changes of RailCom data of subscribed locomotives are sent automatically.  
Z21 Broadcast messages see 8.1 LAN\_RAILCOM\_DATACHANGED
- 0x00000100 Changes of the Z21 system status are sent automatically.  
Z21 Broadcast messages see 2.18 LAN\_SYSTEMSTATE\_DATACHANGED

### From Z21 FW Version 1.20:

- 0x00010000 Extends flag 0x00000001; client now gets LAN\_X\_LOCO\_INFO LAN\_X\_LOCO\_INFO without having to subscribe to the corresponding locomotive addresses, i.e. for all controlled locomotives!  
Due to the high network traffic, this flag may only be used by adequate PC railroad automation software and is **NOT intended for mobile hand controllers** under any circumstances.  
From FW V1.20 bis V1.23: LAN\_X\_LOCO\_INFO is sent for **all** locomotives.  
From **FW V1.24**: LAN\_X\_LOCO\_INFO is sent for **all modified** locomotives.
- 0x01000000 Forwarding messages from LocoNet bus to LAN client without locos and switches.
- 0x02000000 Forwarding locomotive-specific LocoNet messages to LAN Client:  
OPC\_LOCO\_SPD, OPC\_LOCO\_DIRF, OPC\_LOCO\_SND, OPC\_LOCO\_F912, OPC\_EXP\_CMD
- 0x04000000 Forwarding switch-specific LocoNet messages to LAN client:  
OPC\_SW\_REQ, OPC\_SW\_REP, OPC\_SW\_ACK, OPC\_SW\_STATE

See also chapter 9 LocoNet.

### From Z21 FW Version 1.22:

- 0x08000000 Sending status changes of LocoNet track occupancy detectors to the LAN client.  
See 9.5 LAN\_LOCONET\_DETECTOR

### From Z21 FW Version 1.29:

- 0x00040000 Sending changes of RailCom data to the LAN Client.  
Client gets LAN\_RAILCOM\_DATACHANGED without having to subscribe to the corresponding locomotive addresses, i.e. for all controlled locomotives! Due to the high network traffic, this flag may only be used by adequate PC railroad automation software and is **NOT intended for mobile hand controllers** under any circumstances.  
Z21 Broadcast messages see 8.1 LAN\_RAILCOM\_DATACHANGED

**From Z21 FW Version 1.30:**

0x00080000 Sending status changes of CAN-Bus track occupancy detectors to the LAN client.  
See **10.1 LAN\_CAN\_DETECTOR**

Reply from Z21:  
none

**When preparing the settings for the broadcast flags, always consider the effects on the network load. This applies in particular to the broadcast flags 0x00010000, 0x00040000, 0x02000000 and 0x04000000!** The IP packets may be deleted by the router in case of overload and UDP does not offer any detection mechanisms for this! For example, before using flag 0x00000100 (system status) it is worth considering whether 0x00000001 with the corresponding LAN\_X\_BC\_XXX broadcast messages would be a more suitable alternative. Not every application needs to be regularly informed in detail about the latest voltage, current and temperature values of the Z21.

**2.17 LAN\_GET\_BROADCASTFLAGS**

Reading the broadcast flags in the Z21.

Request to Z21:

DataLen		Header		Data
0x04	0x00	0x51	0x00	-

Reply from Z21:

DataLen		Header		Data
0x08	0x00	0x51	0x00	Broadcast-Flags 32 Bit (little endian)

Broadcast-Flags see above.

**2.18 LAN\_SYSTEMSTATE\_DATACHANGED**

Reports a change in the system status from the Z21 to the client.

This message is asynchronously reported to the client by the Z21 when the client

- activated the corresponding broadcast, see **2.16 LAN\_SET\_BROADCASTFLAGS**, Flag 0x00000100.
- explicitly requested the system status, see **2.19 LAN\_SYSTEMSTATE\_GETDATA**.

Z21 to Client:

DataLen		Header		Data
0x14	0x00	0x84	0x00	<b>SystemState (16 Bytes)</b>

**SystemState** is structured as follows (the 16-bit values are little endian):

Byte Offset	Typ	Name		
0	INT16	MainCurrent	mA	Current on the main track
2	INT16	ProgCurrent	mA	Current on programming track
4	INT16	FilteredMainCurrent	mA	smoothed current on the main track
6	INT16	Temperature	°C	command station internal temperature
8	UINT16	SupplyVoltage	mV	supply voltage
10	UINT16	VCCVoltage	mV	internal voltage, identical to track voltage
12	UINT8	CentralState	bitmask	see below
13	UINT8	CentralStateEx	bitmask	see below
14	UINT8	reserved		
15	UINT8	reserved		

**Bitmask for CentralState:**

```
#define csEmergencyStop      0x01 // The emergency stop is switched on
#define csTrackVoltageOff   0x02 // The track voltage is switched off
#define csShortCircuit      0x04 // Short-circuit
#define csProgrammingModeActive 0x20 // The programming mode is active
```

**Bitmask for CentralStateEx:**

```
#define cseHighTemperature  0x01 // temperature too high
#define csePowerLost        0x02 // Input voltage too low
#define cseShortCircuitExternal 0x04 // S.C. at the external booster output
#define cseShortCircuitInternal 0x08 // S.C. at the main track or programming track
```

**2.19 LAN\_SYSTEMSTATE\_GETDATA**

Request the current system status.

Request to Z21:

DataLen		Header		Data
0x04	0x00	0x85	0x00	-

Reply from Z21:

see above **2.18** LAN\_SYSTEMSTATE\_DATACHANGED

**2.20 LAN\_GET\_HWINFO**

From Z21 FW Version 1.20 and SmartRail FW Version V1.13.

Read the hardware type and the firmware version of the Z21.

Request to Z21:

DataLen		Header		Data
0x04	0x00	0x1A	0x00	-

Reply from Z21:

DataLen		Header		Data	
0x0C	0x00	0x1A	0x00	HwType 32 Bit (little endian)	FW Version 32 Bit (little endian)

**HwType:**

```
#define D_HWT_Z21_OLD      0x00000200 // „black Z21“ (hardware variant from 2012)
#define D_HWT_Z21_NEW     0x00000201 // „black Z21“ (hardware variant from 2013)
#define D_HWT_SMARTRAIL   0x00000202 // SmartRail (from 2012)
#define D_HWT_z21_SMALL   0x00000203 // „white z21“ starter set variant (from 2013)
#define D_HWT_z21_START   0x00000204 // „z21 start“ starter set variant (from 2016)
```

The **FW version** is specified in BCD format.

Example:

```
0x0C 0x00 0x1A 0x00 0x00 0x02 0x00 0x00 0x20 0x01 0x00 0x00
```

means: „Hardware Type **0x200**, Firmware Version **1.20**“

To read out the version of an older firmware, use the alternative command

**2.15** LAN\_X\_GET\_FIRMWARE\_VERSION. Apply following rules for older firmware versions:

- V1.10 ... Z21 (hardware variant from 2012)
- V1.11 ... Z21 (hardware variant from 2012)
- V1.12 ... SmartRail (from 2012)

## 2.21 LAN\_GET\_CODE

Read the software feature scope of the Z21 (and z21 or z21start of course).

This command is of particular interest for the hardware variant "z21 start", in order to be able to check whether driving and switching via LAN is blocked or permitted.

Request to Z21:

DataLen		Header		Data
0x04	0x00	0x18	0x00	-

Reply from Z21:

DataLen		Header		Data
0x05	0x00	0x18	0x00	Code (8 Bit)

**Code:**

```
#define Z21_NO_LOCK          0x00 // all features permitted
#define z21_START_LOCKED    0x01 // „z21 start“: driving and switching is blocked
#define z21_START_UNLOCKED 0x02 // „z21 start“: driving and switching is permitted
```

## 3 Settings

The following settings described here are stored in the Z21 persistently. These settings can be reset by the user to the factory settings by keeping the STOP button on the Z21 pressed until the LEDs flash violet.

### 3.1 LAN\_GET\_LOCOMODE

Read the output format for a given locomotive address.

In the Z21, the output format (DCC, MM) is persistently stored for each locomotive address. A maximum of 256 different locomotive addresses can be stored. Each address  $\geq 256$  is DCC automatically.

Request to Z21:

DataLen		Header		Data
0x06	0x00	0x60	0x00	16 bits Loco-Address ( <b>big endian</b> )

Reply from Z21:

DataLen		Header		Data
0x07	0x00	0x60	0x00	16 bits Loco-Address ( <b>big endian</b> )   Mode 8 bit

Loco Address 2 Bytes, **big endian**, i.e. first comes high byte, followed by low byte.

Mode 0 ... DCC Format  
1 ... MM Format

### 3.2 LAN\_SET\_LOCOMODE

Set the output format for a given locomotive address. The format is stored in the Z21 persistently.

Request to Z21:

DataLen		Header		Data
0x07	0x00	0x61	0x00	Loco address 16 Bit ( <b>big endian</b> )   Modus 8 bit

Reply from Z21:

none

Meaning of the values: see above.

**Note:** each locomotive address  $\geq 256$  is and remains "Format DCC" automatically.

**Note:** the speed steps (14, 28, 128) are also stored in the command station persistently. This automatically happens with the loco driving command, see **4.2 LAN\_X\_SET\_LOCO\_DRIVE**.

### 3.3 LAN\_GET\_TURNOUTMODE

Read the settings for a given accessory decoder address ("Accessory Decoder" RP-9.2.1).

In the Z21, the output format (DCC, MM) is persistently stored for each accessory decoder address. A maximum of 256 different accessory decoder addresses can be stored. Each address  $\geq 256$  automatically is DCC.

Request to Z21:

DataLen		Header		Data
0x06	0x00	0x70	0x00	16 bits Accessory Decoder Address ( <b>big endian</b> )

Reply from Z21:

DataLen		Header		Data
0x07	0x00	0x70	0x00	16 bits Accessory Decoder Address ( <b>big endian</b> )   Mode 8 bit

Accessory Decoder Address    2 Bytes, **big endian**, i.e. first comes high byte, followed by low byte.

Mode                                0 ... DCC Format  
     1 ... MM Format

At the LAN interface and in the Z21, the accessory decoder addresses are addressed from 0, but in the visualization in the apps or on the multiMaus from 1. This is only a decision of the visualization.  
 Example: multiMaus switch address #3, corresponds to address 2 on the LAN and in Z21.

### 3.4 LAN\_SET\_TURNOUTMODE

Set the output format for a given accessory decoder address. The format is stored in the Z21 persistently.

Request to Z21:

DataLen		Header		Data
0x07	0x00	0x71	0x00	16 bits Accessory Decoder Address ( <b>big endian</b> )   Mode 8 bit

Reply from Z21:  
 none

Meaning of the values: see above.

MM accessory decoders are supported by Z21 firmware version 1.20 and higher.  
 MM accessory decoders are not supported by SmartRail.

**Note:** Each accessory decoder  $\geq 256$  is and remains DCC automatically.

## 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.

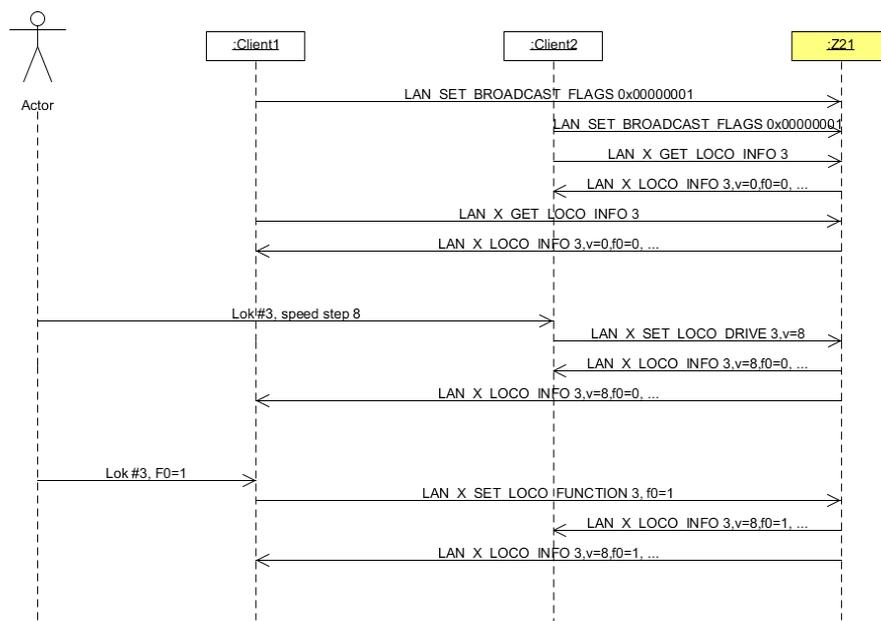


Figure 2 Example sequence: locomotive control

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

Note: loco address = (Adr\_MSB & 0x3F) << 8 + Adr\_LSB

For locomotive addresses  $\geq 128$ , 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					
0x0A	0x00	0x40	0x00	X-Header	DB0	DB1	DB2	DB3	XOR-Byte
				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.

**0x1S**      Number of speed steps, depending on the rail format set  
 S=0: DCC 14 speed steps, or MM1 with 14 speed steps and F0  
 S=2: DCC 28 speed steps, or MM2 with 14 real speed steps and F0-F4  
 S=3: DCC 128 speed steps (aka “126 speed steps” when not counting the stops),  
 or MM2 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 XpressNet™ (X-BUS), i.e. also 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<sub>5</sub>):

R00V <sub>5</sub> VVVV	Speed	R00V <sub>5</sub> VVVV	Speed	R00V <sub>5</sub> VVVV	Speed	R00V <sub>5</sub> VVVV	Speed
R000 0000	Stop	R000 0100	Step 5	R000 1000	Step 13	R000 1100	Step 21
R001 0000	Stop <sup>1</sup>	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 <sup>1</sup>	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

<sup>1</sup> 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 LAN\_X\_SET\_LOCO\_FUNCTION

Change a function of a locomotive.

Request to Z21:

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

Note: loco address = (Adr\_MSB & 0x3F) << 8 + Adr\_LSB

For locomotive addresses  $\geq 128$ , 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.

Reply from Z21:

No standard reply, 4.4 LAN\_X\_LOCO\_INFO to subscribed clients.

#### 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									
7 + n	0x00	0x40	0x00	X-Header	DB0	...	...	...	...	...	...	DBn	XOR-Byte
				0xEF	Locomotive Information								XOR-Byte

The actual packet length  $n$  may vary depending on the data actually sent, with  $7 \leq n \leq 14$ .

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	0000BKKK	<p><b>B</b>=1 ... the locomotive is controlled by another X-BUS handset controller ("busy")</p> <p><b>KKK</b> ... Speed steps information: 0=14, 2=28, 4=128</p> <p>0: DCC 14 speed steps, or MMI with 14 speed steps and F0</p> <p>2: DCC 28 speed steps, or MMII with 14 real speed stages and F0-F4</p> <p>4: DCC 128 speed steps, or MMII with 28 real speed stages (light-trit) and F0-F4</p>
DB3	RVVVVVVV	<p><b>R</b> ... Direction: 1=forward</p> <p><b>V</b> ... Speed. Coding also depends on the speed steps information KKK. See also above section 4.2 LAN_X_SET_LOCO_DRIVE.</p> <p>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.</p>
DB4	0DSLFGHJ	<p><b>D</b> ... double traction: 1=Loco included in a double traction</p> <p><b>S</b> ... Smartsearch</p> <p><b>L</b> ... F0 (Licht)</p> <p><b>F</b> ... F4</p> <p><b>G</b> ... F3</p> <p><b>H</b> ... F2</p> <p><b>J</b> ... F1</p>
DB5	F5-F12	Function F5 is bit0 (LSB)
DB6	F13-F20	Function F13 is bit0 (LSB)
DB7	F21-F28	Function F21 is bit0 (LSB)
DBn		optional, for future extensions

## 5 Switching

This chapter deals with messages which are required for switching accessory decoders ("Accessory Decoder" according RP-9.2.1, e.g. decoder for turnouts, ...).

The visualization of the turnout number on the user interface is differently solved in some DCC systems and can significantly differ from the real DCC accessory decoder address plus port actually used in the track signal. According to DCC, there are four ports with two outputs each per accessory decoder address. One turnout can be connected per port. Usually one of the following options is used to visualize the turnout number:

1. Numbering from 1 with DCC address at 1 starting with 4 ports each (ESU, Uhlenbrock, ...)
  - Switch #1: DCC-Addr=1 Port=0; Switch #5: DCC-Addr=2 Port=0; Switch #6: DCC-Addr=2 Port=1
2. Numbering from 1 with DCC address at 0 starting with 4 ports each (Roco)
  - Switch #1: DCC-Addr=0 Port=0; Switch #5: DCC-Addr=1 Port=0; Switch #6: DCC-Addr=1 Port=1
3. Virtual switch number with freely configurable DCC address and port (Twin Center)
4. Displaying real DCC-address and port number (Zimo)

None of these visualization options can be described as "wrong" due to lack of specification in RP-9.2.1, where the visualization to the user is not mentioned at all. For the user, however, this can mean in consequence getting used to the fact that one and the same turnout at an ESU control panel is controlled under number 1, while it is switched on the Roco multiMaus and Z21 under number 5 ("shift by 4").

In order to be able to implement the visualization of your choice in your application, it helps to know how the Z21 converts the input parameters for the switching commands (**FAdr\_MSB**, **FAdr\_LSB**, **A**, **P**, see below) into the corresponding DCC accessory command:

DCC basic accessory decoder packet format: {preamble} 0 10AAAAAA 0 1 $\underline{aaa}$ CDD $\underline{d}$  0 EEEEEEEE 1

UINT16  $FAdr = (FAdr\_MSB \ll 8) + FAdr\_LSB;$

UINT16  $Dcc\_Addr = FAdr \gg 2;$

$\underline{aaa}$ AAAAAA =  $(\sim Dcc\_Addr \& 0x1C0) | (Dcc\_Addr \& 0x003F);$  // DCC Address

**C** = **A**; // Activate or deactivate output

**DD** =  $FAdr \& 0x03;$  // Port

$\underline{d}$  = **P**; // Switch to the left or to the right

Example:

FAdr=0 equals DCC-Addr=0 Port=0;

FAdr=3 equals DCC-Addr=0 Port=3;

FAdr=4 equals DCC-Addr=1 Port=0; etc.

On the other hand, for MM Format note: FAdr starts with 0, i.e. FAdr=0: MM-Addr=1; FAdr=1: MM-Addr=2; ...

A client can subscribe to accessory info in order to be automatically notified of changes to accessory decoders caused by other clients or handsets. For this purpose, the corresponding broadcast must be activated for the client, see **2.16 LAN\_SET\_BROADCASTFLAGS**, Flag 0x00000001.

The actual position of the turnout depends on the cabling and possibly also on the configuration in the client's application. The command station cannot know anything about this, and that is why the following description deliberately omits the terms "*straight*" and "*branching*". Instead we will speak about "output 1" and "output 2".

### 5.1 LAN\_X\_GET\_TURNOUT\_INFO

The following command can be used to poll the status of a turnout (or any accessory function).

Request to Z21:

DataLen		Header		Data			
0x08	0x00	0x40	0x00	X-Header	DB0	DB1	XOR-Byte
				0x43	FAdr_MSB	FAdr_LSB	XOR-Byte

Note: Function address = (FAdr\_MSB << 8) + FAdr\_LSB

Reply from Z21:  
see 5.3 LAN\_X\_TURNOUT\_INFO

### 5.2 LAN\_X\_SET\_TURNOUT

A turnout (or any accessory function) can be switched with the following command.

Request to Z21:

DataLen		Header		Data				
0x09	0x00	0x40	0x00	X-Header	DB0	DB1	DB2	XOR-Byte
				0x53	FAdr_MSB	FAdr_LSB	10Q0A00P	XOR-Byte

Note: Function address = (FAdr\_MSB << 8) + FAdr\_LSB

1000A00P     **A**=0 ... Deactivate turnout output  
**A**=1 ... Activate turnout output  
**P**=0 ... Select output 1 of the turnout  
**P**=1 ... Select output 2 of the turnout  
**Q**=0 ... Execute command immediately  
**Q**=1 ... **From Z21 FW V1.24:** Insert turnout command into the queue of Z21 and deliver it as soon as possible to the track.

Reply from Z21:  
No standard answer, 5.3 LAN\_X\_TURNOUT\_INFO to subscribed clients.

**From Z21 FW V1.24** the Q flag ("Queue") was introduced.

#### 5.2.1 LAN\_X\_SET\_TURNOUT with Q=0

With **Q=0** the Z21 behaves compatible to the previous versions: the turnout switching command is immediately sent on the track by being mixed into the running loco driving commands. **The Activate (A=1) is output until the LAN client sends the corresponding Deactivate. Only one switching command may be active at the same time.** This behavior corresponds, for example, to pressing and releasing the multiMaus key.

Please note that with Q=0 the correct sequence of the switching commands (i.e. Activate followed by Deactivate) must be observed strictly. Otherwise, undefined end positions may occur depending on the turnout decoder used.

**The LAN client is responsible for the correct serialization and the timing of the switching duration!**

**Wrong:**

Activate turnout #5/A2 (4,0x89); Activate turnout #6/A2 (5,0x89);  
 Activate turnout #3/A1 (2,0x88); Deactivate turnout #3/A1 (2,0x80);  
 Deactivate turnout #5/A2 (4,0x81); Deactivate turnout #6/A2 (5,0x81);

**Correct:**

Activate turnout #5/A2 (4,0x89); wait 100ms; deactivate turnout #5/A2 (4,0x81); wait 50ms;  
 Activate turnout #6/A2 (5,0x89); wait 100ms; deactivate turnout #6/A2 (5,0x81); wait 50ms;  
 Activate turnout #3/A1 (2,0x88); wait 100ms; deactivate turnout #3/A1 (2,0x80); wait 50ms;

**Example:**

Activate turnout #7 / A2 (6,0x89); wait 150ms; deactivate turnout #7 / A2 (6,0x81)

```
DCC preamble=16 LOCO address=3 ss128=0 fwd Speed=Stop
DCC preamble=16 LOCO address=3 FG1 (0-4) F=Loooo
DCC preamble=16 LOCO address=3 FG2 (5-8) F=o7oo
DCC preamble=16 ACCESSORY raw data AA=1 DD=5 C=1 , "Roco_lenz f=7 out=A ACTIVE"
DCC preamble=16 LOCO address=3 ss128=0 fwd Speed=Stop
DCC preamble=16 ACCESSORY raw data AA=1 DD=5 C=1 , "Roco_lenz f=7 out=A ACTIVE"
DCC preamble=16 LOCO address=3 FG1 (0-4) F=Loooo
DCC preamble=16 ACCESSORY raw data AA=1 DD=5 C=1 , "Roco_lenz f=7 out=A ACTIVE"
DCC preamble=16 LOCO address=3 FG2 (5-8) F=o7oo
DCC preamble=16 ACCESSORY raw data AA=1 DD=5 C=1 , "Roco_lenz f=7 out=A ACTIVE"
DCC preamble=16 LOCO address=3 ss128=0 fwd Speed=Stop
DCC preamble=16 ACCESSORY raw data AA=1 DD=5 C=1 , "Roco_lenz f=7 out=A ACTIVE"
DCC preamble=16 LOCO address=3 FG1 (0-4) F=Loooo
DCC preamble=16 ACCESSORY raw data AA=1 DD=5 C=1 , "Roco_lenz f=7 out=A ACTIVE"
DCC preamble=16 LOCO address=3 FG2 (5-8) F=o7oo
DCC preamble=16 ACCESSORY raw data AA=1 DD=5 C=1 , "Roco_lenz f=7 out=A ACTIVE"
DCC preamble=16 LOCO address=3 ss128=0 fwd Speed=Stop
DCC preamble=16 ACCESSORY raw data AA=1 DD=5 C=1 , "Roco_lenz f=7 out=A ACTIVE"
DCC preamble=16 LOCO address=3 FG1 (0-4) F=Loooo
DCC preamble=16 ACCESSORY raw data AA=1 DD=5 C=1 , "Roco_lenz f=7 out=A ACTIVE"
DCC preamble=16 LOCO address=3 FG2 (5-8) F=o7oo
DCC preamble=16 ACCESSORY raw data AA=1 DD=5 C=1 , "Roco_lenz f=7 out=A ACTIVE"
DCC preamble=16 LOCO address=3 ss128=0 fwd Speed=Stop
DCC preamble=16 ACCESSORY raw data AA=1 DD=5 C=1 , "Roco_lenz f=7 out=A ACTIVE"
DCC preamble=16 LOCO address=3 FG1 (0-4) F=Loooo
DCC preamble=16 ACCESSORY raw data AA=1 DD=5 C=1 , "Roco_lenz f=7 out=A ACTIVE"
DCC preamble=16 LOCO address=3 FG2 (5-8) F=o7oo
DCC preamble=16 ACCESSORY raw data AA=1 DD=5 C=1 , "Roco_lenz f=7 out=A ACTIVE"
DCC preamble=16 LOCO address=3 ss128=0 fwd Speed=Stop
DCC preamble=16 ACCESSORY raw data AA=1 DD=5 C=1 , "Roco_lenz f=7 out=A ACTIVE"
DCC preamble=16 LOCO address=3 FG1 (0-4) F=Loooo
DCC preamble=16 ACCESSORY raw data AA=1 DD=5 C=0 , "Roco_lenz f=7 out=A INACTIVE"
DCC preamble=16 LOCO address=3 FG2 (5-8) F=o7oo
DCC preamble=16 ACCESSORY raw data AA=1 DD=5 C=0 , "Roco_lenz f=7 out=A INACTIVE"
DCC preamble=16 LOCO address=3 ss128=0 fwd Speed=Stop
DCC preamble=16 ACCESSORY raw data AA=1 DD=5 C=0 , "Roco_lenz f=7 out=A INACTIVE"
DCC preamble=16 LOCO address=3 FG1 (0-4) F=Loooo
DCC preamble=16 ACCESSORY raw data AA=1 DD=5 C=0 , "Roco_lenz f=7 out=A INACTIVE"
DCC preamble=16 LOCO address=3 FG2 (5-8) F=o7oo
DCC preamble=16 LOCO address=3 ss128=0 fwd Speed=Stop
DCC preamble=16 LOCO address=3 FG1 (0-4) F=Loooo
```

**Figure 3 DCC Sniff on track with Q=0**

## 5.2.2 LAN\_X\_SET\_TURNOUT with Q=1

If **Q=1**, the following behavior occurs: in the Z21 the switching command is first put into an internal queue (FIFO). When generating the track signal, this queue is constantly checked whether a switching command is available for output. This switching command is then taken out of the queue and is written four times onto the track. This liberates the LAN client from the obligation of strict serialization, i.e. the switching commands may be sent mixed to the Z21 with Q=1 (very useful routes!). The LAN client only needs to take care of the Deactivate timing. Depending on the DCC decoder, the Deactivate may even be omitted. With MM you should not do without Deactivate, because e.g. the k83 and some older turnout decoders do not have an automatic shut-off.

Example:

Activate turnout #25 / A2 (24, 0xA9); Activate turnout #5 / A2 (4, 0xA9);

Wait 150ms;

Deactivate turnout #25 / A2 (24, 0xA1)

```

DCC preamble=16 LOCO address=3 ss128=0 fwd Speed=Stop
DCC preamble=16 LOCO address=3 ss128=0 fwd Speed=Stop
DCC preamble=16 LOCO address=3 ss128=0 fwd Speed=Stop
DCC preamble=16 ACCESSORY raw data AA=6 DD=1 C=1 , "Roco_lenz f=25 out=A ACTIVE"
DCC preamble=16 LOCO address=3 ss128=0 fwd Speed=Stop
DCC preamble=16 ACCESSORY raw data AA=6 DD=1 C=1 , "Roco_lenz f=25 out=A ACTIVE"
DCC preamble=16 LOCO address=3 ss128=0 fwd Speed=Stop
DCC preamble=16 ACCESSORY raw data AA=6 DD=1 C=1 , "Roco_lenz f=25 out=A ACTIVE"
DCC preamble=16 LOCO address=3 ss128=0 fwd Speed=Stop
DCC preamble=16 ACCESSORY raw data AA=6 DD=1 C=1 , "Roco_lenz f=25 out=A ACTIVE"
DCC preamble=16 LOCO address=3 ss128=0 fwd Speed=Stop
DCC preamble=16 ACCESSORY raw data AA=1 DD=1 C=1 , "Roco_lenz f=5 out=A ACTIVE"
DCC preamble=16 LOCO address=3 ss128=0 fwd Speed=Stop
DCC preamble=16 ACCESSORY raw data AA=1 DD=1 C=1 , "Roco_lenz f=5 out=A ACTIVE"
DCC preamble=16 LOCO address=3 ss128=0 fwd Speed=Stop
DCC preamble=16 ACCESSORY raw data AA=1 DD=1 C=1 , "Roco_lenz f=5 out=A ACTIVE"
DCC preamble=16 LOCO address=3 ss128=0 fwd Speed=Stop
DCC preamble=16 ACCESSORY raw data AA=1 DD=1 C=1 , "Roco_lenz f=5 out=A ACTIVE"
DCC preamble=16 LOCO address=3 ss128=0 fwd Speed=Stop
DCC preamble=16 ACCESSORY raw data AA=6 DD=1 C=0 , "Roco_lenz f=25 out=A INACTIVE"
DCC preamble=16 LOCO address=3 ss128=0 fwd Speed=Stop
DCC preamble=16 ACCESSORY raw data AA=6 DD=1 C=0 , "Roco_lenz f=25 out=A INACTIVE"
DCC preamble=16 LOCO address=3 ss128=0 fwd Speed=Stop
DCC preamble=16 ACCESSORY raw data AA=6 DD=1 C=0 , "Roco_lenz f=25 out=A INACTIVE"
DCC preamble=16 LOCO address=3 ss128=0 fwd Speed=Stop
DCC preamble=16 ACCESSORY raw data AA=6 DD=1 C=0 , "Roco_lenz f=25 out=A INACTIVE"
DCC preamble=16 LOCO address=3 ss128=0 fwd Speed=Stop
DCC preamble=16 LOCO address=3 ss128=0 fwd Speed=Stop
DCC preamble=16 LOCO address=3 ss128=0 fwd Speed=Stop

```

**Figure 4 DCC Sniff on track with Q=1**

Never mix switching commands with Q=0 and switching commands with Q=1 in your application.

### 5.3 LAN\_X\_TURNOUT\_INFO

This message is sent from the Z21 to the clients in response to the command 5.1 LAN\_X\_GET\_TURNOUT\_INFO. However, it is also sent to an associated client unsolicitedly if

- the function status has been changed by one of the (other) clients or a handset controller
- and the associated client has activated the corresponding broadcast, see 2.16 LAN\_SET\_BROADCASTFLAGS, Flag 0x00000001

Z21 to Client:

DataLen		Header		Data				
0x09	0x00	0x40	0x00	X-Header	DB0	DB1	DB2	XOR-Byte
				0x43	FAdr_MSB	FAdr_LSB	000000ZZ	XOR-Byte

Note: Function address = (FAdr\_MSB << 8) + FAdr\_LSB

000000ZZ      ZZ=00 ... Turnout not switched yet  
 ZZ=01 ... Turnout is in position according to switching command "P=0", see 5.2 LAN\_X\_SET\_TURNOUT  
 ZZ=10 ... Turnout is in position according to switching command "P=1", see 5.2 LAN\_X\_SET\_TURNOUT  
 ZZ=11 ... Invalid combination

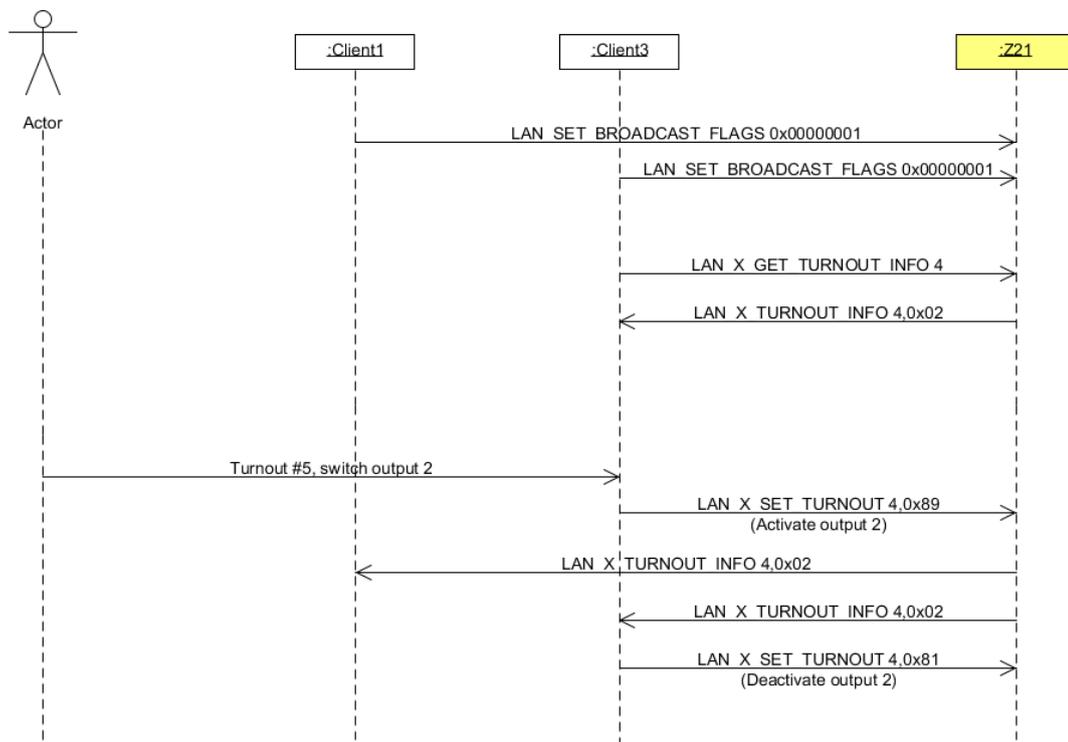


Figure 5 Example Sequence: Turnout switching

## 6 Reading and writing Decoder CVs

This chapter deals with messages required for reading and writing decoder CVs (Configuration Variable, RP-9.2.2, RP-9.2.3).

Whether the decoder is accessed bit-wise or byte-wise depends on the settings in the Z21.

### 6.1 LAN\_X\_CV\_READ

Read a CV in direct mode.

Request to Z21:

DataLen		Header		Data				
0x09	0x00	0x40	0x00	X-Header	DB0	DB1	DB2	XOR-Byte
				0x23	0x11	CVAdr_MSB	CVAdr_LSB	XOR-Byte

Note: CV Address = (CVAdr\_MSB << 8) + CVAdr\_LSB, where 0=CV1, 1=CV2, 255=CV256, etc.

Reply from Z21:

2.9 LAN\_X\_BC\_PROGRAMMING\_MODE to subscribed clients, as well as the result  
6.3 LAN\_X\_CV\_NACK\_SC, 6.4 LAN\_X\_CV\_NACK or 6.5 LAN\_X\_CV\_RESULT.

### 6.2 LAN\_X\_CV\_WRITE

Write a CV in direct mode.

Request to Z21:

DataLen		Header		Data					
0x0A	0x00	0x40	0x00	X-Header	DB0	DB1	DB2	DB3	XOR-Byte
				0x24	0x12	CVAdr_MSB	CVAdr_LSB	Value	XOR-Byte

Note: CV-Address = (CVAdr\_MSB << 8) + CVAdr\_LSB, where 0=CV1, 1=CV2, 255=CV256, etc.

Reply from Z21:

2.9 LAN\_X\_BC\_PROGRAMMING\_MODE to subscribed clients, as well as the result  
6.3 LAN\_X\_CV\_NACK\_SC, 6.4 LAN\_X\_CV\_NACK or 6.5 LAN\_X\_CV\_RESULT.

### 6.3 LAN\_X\_CV\_NACK\_SC

If the programming failed due to a short circuit on the track, this message is automatically sent to the client that initiated the programming by 6.1 LAN\_X\_CV\_READ or 6.2 LAN\_X\_CV\_WRITE.

Z21 to Client:

DataLen		Header		Data		
0x07	0x00	0x40	0x00	X-Header	DB0	XOR-Byte
				0x61	0x12	0x73

### 6.4 LAN\_X\_CV\_NACK

If the ACK is missing from the decoder, this message is automatically sent to the client that initiated the programming by 6.1 LAN\_X\_CV\_READ or 6.2 LAN\_X\_CV\_WRITE.  
When reading with byte-wise access, the time until LAN\_X\_CV\_NACK can be very long.

Z21 to Client:

DataLen		Header		Data		
0x07	0x00	0x40	0x00	X-Header	DB0	XOR-Byte
				0x61	0x13	0x72

### 6.5 LAN\_X\_CV\_RESULT

This message is also a "positive ACK" and is automatically sent to the client that initiated the programming by 6.1 LAN\_X\_CV\_READ or 6.2 LAN\_X\_CV\_WRITE.  
When reading with byte-wise access, the time until LAN\_X\_CV\_RESULT can be very long.

Z21 to Client:

DataLen		Header		Data					
0x0A	0x00	0x40	0x00	X-Header	DB0	DB1	DB2	DB3	XOR-Byte
				0x64	0x14	CVAdr_MSB	CVAdr_LSB	Value	XOR-Byte

Note: CV Address = (CVAdr\_MSB << 8) + CVAdr\_LSB, where 0=CV1, 1=CV2, 255=CV256, etc.

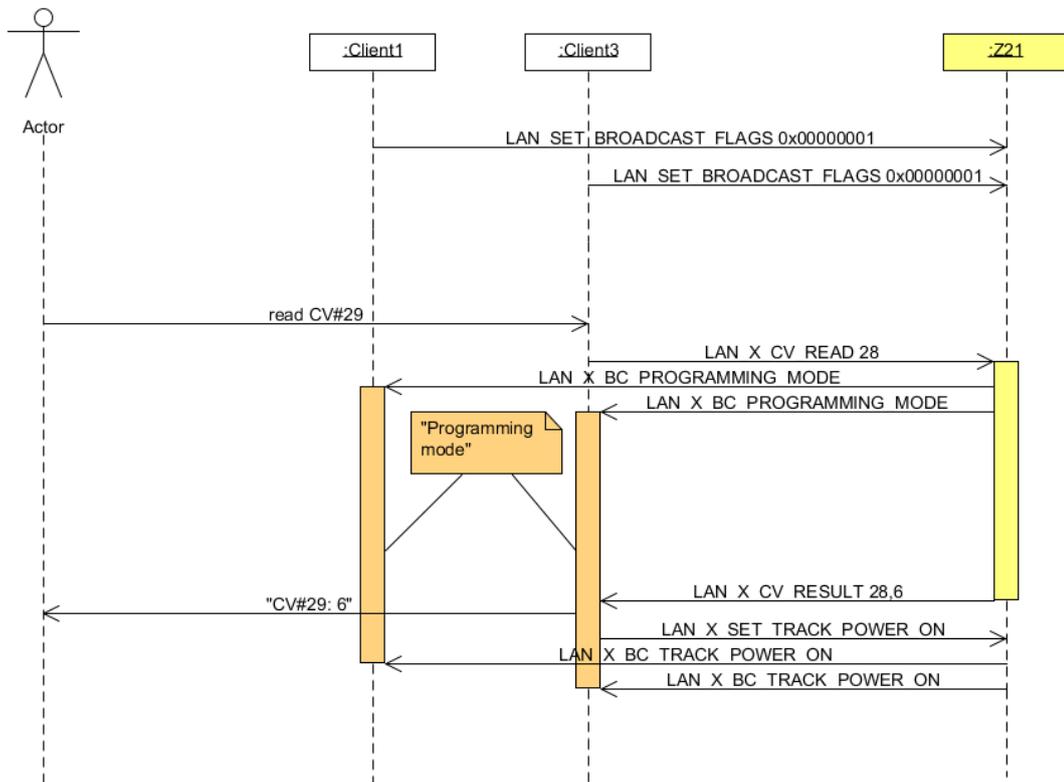


Figure 6 Example Sequence: CV Reading

## 6.6 LAN\_X\_CV\_POM\_WRITE\_BYTE

With the following command a CV of a locomotive decoder (“Multi Function Digital Decoders” according to NMRA S-9.2.1 Section C; Configuration Variable Access Instruction - Long Form) can be written on the main track (POM "Programming on the Main"). This is done in normal operating mode, i.e. the track voltage must be already switched on and the service mode is not activated. There is no feedback.

Request to Z21:

DataLen		Header		Data							
0x0C	0x00	0x40	0x00	X-Header	DB0	DB1	DB2	DB3	DB4	DB5	XOR-Byte
				0xE6	0x30	POM-Parameter					

The data for **POM parameters** is structured as follows:

Position	Data	Meaning
DB1	Adr_MSB	
DB2	Adr_LSB	Loco Address = (Adr_MSB & 0x3F) << 8 + Adr_LSB
DB3	111011MM	Option ... 0xEC MM ... CVAdr_MSB
DB4	CVAdr_LSB	CV Address = (MM << 8) + CVAdr_LSB (0=CV1., 1=CV2, 255=CV256, etc.)
DB5	Value	New CV Value

Reply from Z21:

none

## 6.7 LAN\_X\_CV\_POM\_WRITE\_BIT

With the following command one bit of a CV of a locomotive decoder (“Multi Function Digital Decoders” according to NMRA S-9.2.1 Section C; Configuration Variable Access Instruction - Long Form) can be written on the main track (POM). This is done in normal operating mode, i.e. the track voltage must be already switched on and the service mode is not activated. There is no feedback.

Request to Z21:

DataLen		Header		Data							
0x0C	0x00	0x40	0x00	X-Header	DB0	DB1	DB2	DB3	DB4	DB5	XOR-Byte
				0xE6	0x30	POM-Parameter					

The data for **POM parameters** is structured as follows:

Position	Data	Meaning
DB1	Adr_MSB	
DB2	Adr_LSB	Loco Address = (Adr_MSB & 0x3F) << 8 + Adr_LSB
DB3	111010MM	Option ... 0xE8 MM ... CVAdr_MSB
DB4	CVAdr_LSB	CV Address = (MM << 8) + CVAdr_LSB (0=CV1., 1=CV2, 255=CV256, etc.)
DB5	0000VPPP	PPP ... Bit-Position in CV V ... New CV Value

Reply from Z21:

none

## 6.8 LAN\_X\_CV\_POM\_READ\_BYTE

From Z21 FW Version 1.22.

With the following command a CV of a locomotive decoder (“Multi Function Digital Decoders” according to NMRA S-9.2.1 Section C; Configuration Variable Access Instruction - Long Form) can be read on the main track (POM). This is done in normal operating mode, i.e. the track voltage must be already switched on and the service mode is not activated. RailCom must be activated in the Z21. The vehicle decoder to be read must be capable of RailCom, CV28 bit 0 and 1 as well as CV29 bit 3 must be set to 1 in the locomotive decoder (Zimo).

Request to Z21:

DataLen		Header		Data							
0x0C	0x00	0x40	0x00	X-Header	DB0	DB1	DB2	DB3	DB4	DB5	XOR-Byte
				0xE6	0x30	POM-Parameter					XOR-Byte

The data for **POM parameters** is structured as follows:

Position	Data	Meaning
DB1	Adr_MSB	
DB2	Adr_LSB	Loco Address = (Adr_MSB & 0x3F) << 8 + Adr_LSB
DB3	111010MM	Option ... 0xE4 MM ... CVAdr_MSB
DB4	CVAdr_LSB	CV Address = (MM << 8) + CVAdr_LSB (0=CV1., 1=CV2, 255=CV256, etc.)
DB5	0	

Reply from Z21:

6.4 LAN\_X\_CV\_NACK or 6.5 LAN\_X\_CV\_RESULT.

## 6.9 LAN\_X\_CV\_POM\_ACCESSORY\_WRITE\_BYTE

From Z21 FW Version 1.22.

With the following command a CV of an accessory decoder (according to NMRA S-9.2.1 Section D, “Basic Accessory Decoder Packet address for operations mode programming”) can be written on the main track (POM). This happens in normal operating mode, i.e. the track voltage must be already switched on and the service mode is not activated. There is no feedback.

Request to Z21:

DataLen		Header		Data							
0x0C	0x00	0x40	0x00	X-Header	DB0	DB1	DB2	DB3	DB4	DB5	XOR-Byte
				0xE6	0x31	POM-Parameter					XOR-Byte

The data for **POM parameters** is structured as follows:

Position	Data	Meaning
DB1	aaaaa	Decoder_Address MSB
DB2	AAAACDDD	Note: $aaaaaAAAACDDD = ((\text{Decoder\_Address} \& 0x1FF) \ll 4)   CDDD$ ; In case <b>CDDD</b> =0000, then the CV refers to the whole decoder. In case <b>C</b> =1, then <b>DDD</b> is the number of the output to be programmed.
DB3	111011MM	<b>Option ... 0xEC</b> <b>MM ... CVAdr_MSB</b>
DB4	CVAdr_LSB	CV Address = $(MM \ll 8) + CVAdr\_LSB$ (0=CV1, 1=CV2, 255=CV256, etc.)
DB5	Value	new CV value

Reply from Z21:

none

## 6.10 LAN\_X\_CV\_POM\_ACCESSORY\_WRITE\_BIT

From Z21 FW Version 1.22.

With the following command a CV of an accessory decoder (according to NMRA S-9.2.1 Section D, “Basic Accessory Decoder Packet address for operations mode programming”) can be written on the main track (POM). This happens in normal operating mode, i.e. the track voltage must be already switched on and the service mode is not activated. There is no feedback.

Request to Z21:

DataLen		Header		Data							
0x0C	0x00	0x40	0x00	X-Header	DB0	DB1	DB2	DB3	DB4	DB5	XOR-Byte
				0xE6	0x31	POM-Parameter					XOR-Byte

The data for **POM parameters** is structured as follows:

Position	Data	Meaning
DB1	aaaaa	Decoder_Address MSB
DB2	AAAACDDD	Note: $aaaaaAAAACDDD = ((\text{Decoder\_Address} \& 0x1FF) \ll 4)   CDDD$ ; In case <b>CDDD</b> =0000, then the CV refers to the whole decoder. In case <b>C</b> =1, then <b>DDD</b> is the number of the output to be programmed.
DB3	111010MM	<b>Option ... 0xE8</b> <b>MM ... CVAdr_MSB</b>
DB4	CVAdr_LSB	CV Address = $(MM \ll 8) + CVAdr\_LSB$ (0=CV1, 1=CV2, 255=CV256, etc.)
DB5	0000VPPP	<b>PPP ... Bit position in CV</b> <b>V ... new CV value</b>

Reply from Z21:  
none

### 6.11 LAN\_X\_CV\_POM\_ACCESSORY\_READ\_BYTE

From Z21 FW Version 1.22.

With the following command a CV of an accessory decoder (according to NMRA S-9.2.1 Section D, “Basic Accessory Decoder Packet address for operations mode programming”) can be read on the main track (POM). This happens in normal operating mode, i.e. the track voltage must be already switched on, the service mode is not activated. RailCom must be activated in the Z21. The accessory decoder to be read must be capable of RailCom.

Request to Z21:

DataLen		Header		Data							
0x0C	0x00	0x40	0x00	X-Header	DB0	DB1	DB2	DB3	DB4	DB5	XOR-Byte
				0xE6	0x31	POM-Parameter					

The data for **POM parameters** is structured as follows:

Position	Data	Meaning
DB1	<b>aaaaa</b>	Decoder_Address MSB
DB2	<b>AAAACDDD</b>	Note: <b>aaaaaAAAACDDD</b> = ((Decoder_Address & 0x1FF) << 4)   CDDD; In case <b>CDDD</b> =0000, then the CV refers to the whole decoder. In case <b>C</b> =1, then <b>DDD</b> is the number of the output to be programmed.
DB3	<b>111010MM</b>	<b>Option ... 0xE4</b> <b>MM ... CVAdr_MSB</b>
DB4	<b>CVAdr_LSB</b>	CV Address = ( <b>MM</b> << 8) + <b>CVAdr_LSB</b> (0=CV1, 1=CV2, 255=CV256, etc.)
DB5	<b>0</b>	new CV value

Reply from Z21:  
6.4 LAN\_X\_CV\_NACK or 6.5 LAN\_X\_CV\_RESULT.

## 6.12 LAN\_X\_MM\_WRITE\_BYTE

From Z21 FW Version 1.23.

With the following command a register of a Motorola decoder can be written on the programming track.

Request to Z21:

DataLen		Header		Data					
				X-Header	DB0	DB1	DB2	DB3	XOR-Byte
0x0A	0x00	0x40	0x00	0x24	0xFF	0	RegAdr	Value	XOR-Byte

Note: **RegAdr**: 0=Register1, 1=Register2, ..., 78=Register79.

Note:  $0 \leq \text{Value} \leq 255$ , but some decoders only accept values from 0 to 80.

Reply from Z21:

2.9 LAN\_X\_BC\_PROGRAMMING\_MODE to subscribed clients, as well as the result  
6.3 LAN\_X\_CV\_NACK\_SC or 6.5 LAN\_X\_CV\_RESULT.

**Note:** Programming a Motorola decoder was not possible in the original Motorola format.

Therefore there exists no standardized and binding programming procedure for programming Motorola decoders. However, for the programming of Motorola decoders, the so-called "6021 programming mode" was implemented in the Z21. This allows writing values, but there is no way to read them. Hence the success of the write operation cannot be checked (except for short-circuit detection). This programming procedure works for many ESU, Zimo and Märklin decoders, but not necessarily for all MM decoders. For example, Motorola decoders with DIP switches cannot be programmed. Some decoders only accept values from 0 to 80, others accept values from 0 to 255 (see decoder description).

Since no feedback about the success of the write operation comes from the decoder during Motorola programming, the message *LAN\_X\_CV\_RESULT* is only to be understood as "*MM programming process finished*" and **not** as "*MM programming process successful*".

Example:

**0x0A 0x00 0x40 0x00 0x24 0xFF 0x00 0x00 0x05 0xDE**

meaning: "Change the locomotive decoder address (register 1) to 5"

### 6.13 LAN\_X\_DCC\_READ\_REGISTER

From Z21 FW Version 1.25.

The following command can be used to read a register of a DCC decoder in register mode (S-9.2.3 Service Mode Instruction Packets for Physical Register Addressing) on the programming track.

Request to Z21:

DataLen		Header		Data			
0x08	0x00	0x40	0x00	X-Header	DB0	DB1	XOR-Byte
				0x22	0x11	REG	XOR-Byte

Note: **REG**: 0x01=Register1, 0x02=Register2, ..., 0x08=Register8.

Note:  $0 \leq \text{Value} \leq 255$

Reply from Z21:

2.9 LAN\_X\_BC\_PROGRAMMING\_MODE to subscribed clients, as well as the result

6.3 LAN\_X\_CV\_NACK\_SC or 6.5 LAN\_X\_CV\_RESULT.

**Note:** Programming in register mode is only required for very old DCC decoders. Direct CV is preferred.

### 6.14 LAN\_X\_DCC\_WRITE\_REGISTER

From Z21 FW Version 1.25.

With the following command a register of a DCC decoder in register mode (S-9.2.3 Service Mode Instruction Packets for Physical Register Addressing) can be written on the programming track.

Request to Z21:

DataLen		Header		Data				
0x09	0x00	0x40	0x00	X-Header	DB0	DB2	DB3	XOR-Byte
				0x23	0x12	REG	Value	XOR-Byte

Note: **REG**: 0x01=Register1, 0x02=Register2, ..., 0x08=Register8.

Note:  $0 \leq \text{Value} \leq 255$

Reply from Z21:

2.9 LAN\_X\_BC\_PROGRAMMING\_MODE to subscribed clients, as well as the result

6.3 LAN\_X\_CV\_NACK\_SC or 6.5 LAN\_X\_CV\_RESULT.

**Note:** Programming in register mode is only required for very old DCC decoders. Direct CV is preferred.

## 7 Feedback – R-BUS

The feedback modules (Roco 10787, 10808, 10819) on the R-BUS can be read out and configured with the following commands.

### 7.1 LAN\_RMBUS\_DATACHANGED

Report the changes on the feedback bus from the Z21 to the client.

This message is asynchronously reported to the client by the Z21 when the client

- activated the corresponding broadcast, see **2.16** LAN\_SET\_BROADCASTFLAGS, Flag 0x00000002
- or explicitly requested the feedback status, see below 7.2 LAN\_RMBUS\_GETDATA.

Z21 to Client:

DataLen		Header		Data	
0x0F	0x00	0x80	0x00	Group index (1 Byte)	Feedback status (10 Byte)

**Group index:** 0 ... feedback module with address from 1 to 10  
1 ... feedback module with address from 11 to 20

**Feedback status:** 1 byte per feedback, 1 bit per input.  
The order of feedback address and byte position is ascending.

Example:

Group Index = 1 and Feedback Status = 0x01 0x00 0xC5 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00  
means "feedback module #11, contact on input 1; feedback module #13, contact on input 8,7,3 and 1"

### 7.2 LAN\_RMBUS\_GETDATA

Poll the current status of the feedback modules.

Request to Z21:

DataLen		Header		Data	
0x05	0x00	0x81	0x00	Group index (1 Byte)	

**Group index:** see above

Reply from Z21:

See above 7.1 LAN\_RMBUS\_DATACHANGED

### 7.3 LAN\_RMBUS\_PROGRAMMODULE

Change the address of one feedback module.

Request to Z21:

DataLen		Header		Data
0x05	0x00	0x82	0x00	Address (1 Byte)

**Address:** New address for the feedback module to be programmed.  
Supported value range: 0 and 1 ... 20.

Reply from Z21:  
none

The programming-sequence is transmitted on the R-BUS until this command is sent again to the Z21 with address=0.

Only one single feedback module should be connected to the R-BUS during the programming process.

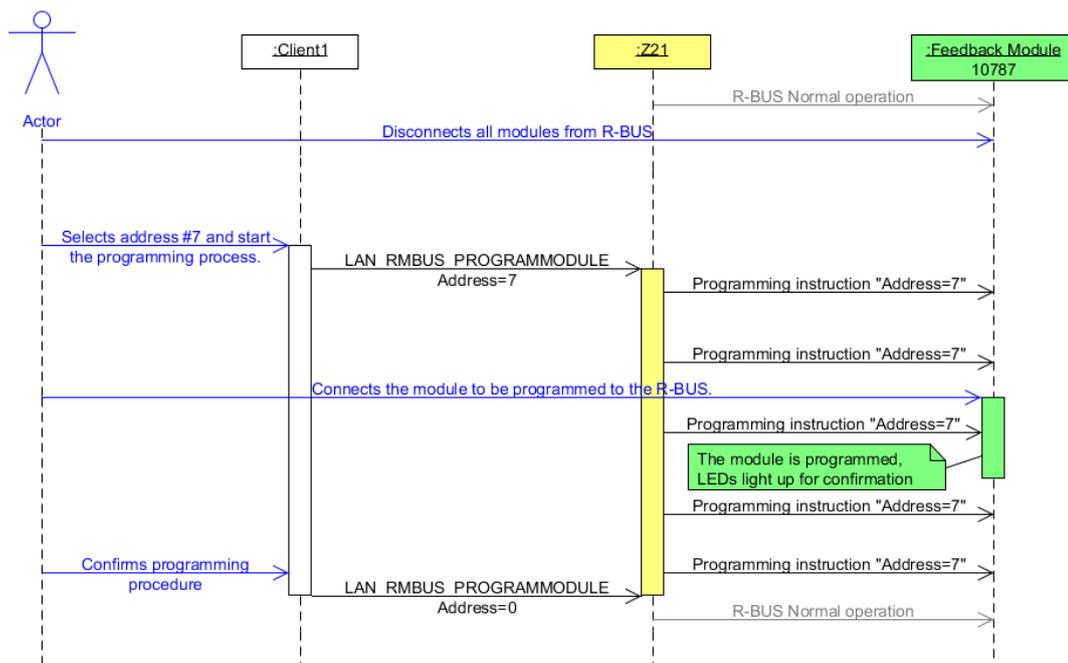


Figure 7 Example Sequence: Programming the feedback module

## 8 RailCom

The Z21 supports RailCom with:

- Generating the RailCom cutout in the track signal.
- Global RailCom receiver in the Z21.
- Local RailCom receivers, e.g. in the occupancy detectors 10808 or boosters 10806 and 10807. The data from RailCom channel 2 of the 10806, 10807 and 10808 can be forwarded via CAN to the Z21 and evaluated there from FW V1.29 onwards.
- Reading POM results.  
See also 6.8 LAN\_X\_CV\_POM\_READ\_BYTE as of FW V1.22.
- Locomotive address recognition for occupancy detectors (CAN, LocoNet, X-BUS).  
See 9.5 LAN\_LOCONET\_DETECTOR from V1.22 and 10.1 LAN\_CAN\_DETECTOR from V1.30.
- Decoder speed (see below) from FW V1.29.
- Decoder QoS (see below) from FW V1.29.

In order to use these features, the decoder must be capable of RailCom, CV28 and CV29 must be correctly configured, and the option "RailCom" must activated in the Z21 settings.

**Note:** It heavily depends on the decoder firmware whether and in which form a decoder supports speed, QoS and POM!

### 8.1 LAN\_RAILCOM\_DATACHANGED

This message is sent to the clients by the Z21 from FW version 1.29 on as a response to the command 8.2 LAN\_RAILCOM\_GETDATA.

However, it is also sent to clients unsolicitedly, if

- the corresponding RailCom data have actually changed
- and the associated client has activated the corresponding broadcast.  
(see 2.16 LAN\_SET\_BROADCASTFLAGS, Flag 0x00000004) and the associated client has subscribed to the locomotive address with 4.1 LAN\_X\_GET\_LOCO\_INFO.
- or the associated client has subscribed to broadcast 0x00040000 (i.e. RailCom data of all locomotives, for PC control SW only).

Z21 to Client:

DataLen		Header		Data
0x11	0x00	0x88	0x00	RailComData

The structure **RailComData** is structured as follows (the 16-bit and 32-bit values are little endian)

Byte Offset	Type	Name	
0	UINT16	LocoAddress	Address of the detected decoder
2	UINT32	ReceiveCounter	Receive counter in Z21
6	UINT16	ErrorCounter	Receive error counter in Z21
8	UINT8	reserved	
9	UINT8	Options	Flags bitmask: #define rcoSpeed1 0x01 // CH7 subindex 0 #define rcoSpeed2 0x02 // CH7 subindex 1 #define rcoQoS 0x04 // CH7 subindex 7
10	UINT8	Speed	Speed 1 or 2 (if supported by decoder)
11	UINT8	QoS	Quality of Service (if supported by decoder)
12	UINT8	reserved	

The structure can be increased in the future versions; therefore it is absolutely necessary to consider DataLen in the evaluation.

## 8.2 LAN\_RAILCOM\_GETDATA

Poll RailCom data from Z21, available from FW V1.29 and higher:

Request to Z21:

DataLen		Header		Data	
0x07	0x00	0x89	0x00	Type 8 bit	LocoAddress 16 bit (little endian)

**Type** 0x01 = poll RailCom data for given locomotive address

**LocoAddress** **Loco address**  
0= poll RailCom data of next loco (circular buffer)

Reply from Z21:

See above 8.2 LAN\_RAILCOM\_DATACHANGED

## 9 LocoNet

From Z21 FW Version 1.20.

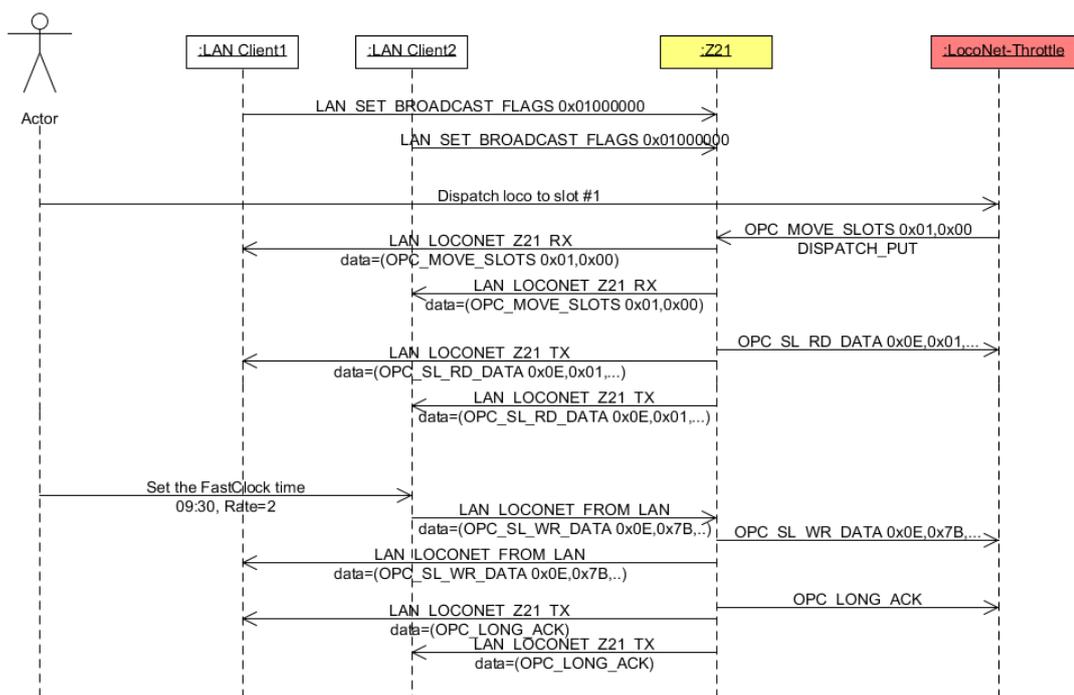
As mentioned in the introduction, the Z21 can be used as an **Ethernet/LoCoNet gateway**, where the Z21 is also the LocoNet master refreshing the slots and generating the DCC packets.

The LAN client can subscribe to the corresponding LocoNet messages using **2.16 LAN\_SET\_BROADCASTFLAGS** in order to receive also the messages from LocoNet.

Messages received by the Z21 from the LocoNet bus are forwarded to the LAN client with the LAN header **LAN\_LOCONET\_Z21\_RX**.

Messages sent by the Z21 onto the LocoNet bus are also forwarded to the LAN client using the LAN header **LAN\_LOCONET\_Z21\_TX**.

With the Z21-LAN command **LAN\_LOCONET\_FROM\_LAN** the LAN client itself can write messages onto the LocoNet bus. If there are other LAN clients with LocoNet subscriptions at the same time, they will also be notified with a message **LAN\_LOCONET\_FROM\_LAN**. Only the actual sender will not be notified.



**Figure 8 Example Sequence: Ethernet/LoCoNet gateway**

This example shows that even with trivial processes on the LocoNet bus, considerable network traffic can simultaneously occur on the Ethernet or WLAN.

Please note that this Ethernet/LoCoNet Gateway functionality has primarily been created for PC control SW as an additional tool for communicating with e.g. LocoNet feedback devices, etc.

When subscribing to the LocoNet messages, you should carefully consider whether the broadcast flags 0x02000000 (LoCoNet locomotives) and 0x04000000 (LoCoNet switches) are really necessary for your application. For conventional driving and switching, in particular, you should better use the LAN commands already described in chapters **4 Driving**, **5 Switching** and **6 Reading and writing Decoder CV**.

The actual LocoNet protocol is not described in more details in this specification. Please directly contact Digitrax or the manufacturer of the respective LocoNet hardware, especially if that manufacturer has extended the LocoNet protocol for e.g. configuration purposes etc.

### 9.1 LAN\_LOCONET\_Z21\_RX

From Z21 FW Version 1.20.

This message is asynchronously reported to the client by the Z21 when the client

- activated the corresponding broadcast, see **2.16** LAN\_SET\_BROADCASTFLAGS, Flags 0x01000000, 0x02000000 or 0x04000000.
- and a message has been received by the Z21 from the LocoNet bus.

Z21 to Client:

DataLen		Header		Data
0x04+n	0x00	0xA0	0x00	LocoNet message incl. CKSUM
				n Bytes

### 9.2 LAN\_LOCONET\_Z21\_TX

From Z21 FW Version 1.20.

This message is asynchronously reported to the client by the Z21 when the client

- activated the corresponding broadcast, see **2.16** LAN\_SET\_BROADCASTFLAGS, Flags 0x01000000, 0x02000000 or 0x04000000.
- and a message has been written to the LocoNet bus by the Z21.

Z21 to Client:

DataLen		Header		Data
0x04+n	0x00	0xA1	0x00	LocoNet message incl. CKSUM
				n Bytes

### 9.3 LAN\_LOCONET\_FROM\_LAN

From Z21 FW Version 1.20.

This message allows a LAN client to write a message to the LocoNet bus.

This message is also asynchronously reported by the Z21 to a client when the client

- activated the corresponding broadcast, see **2.16** LAN\_SET\_BROADCASTFLAGS, Flags 0x01000000, 0x02000000 or 0x04000000.
- and **another** LAN client has written a message to the LocoNet bus via the Z21.

LAN client to Z21, or Z21 to LAN client:

DataLen		Header		Data
0x04+n	0x00	0xA2	0x00	LocoNet message incl. CKSUM
				n Bytes

### 9.3.1 DCC Binary State Control Instruction

**From FW Version V1.25** any DCC packets can be generated at the track output using LAN\_LOCONET\_FROM\_LAN and the LocoNet command OPC\_IMM\_PACKET, among them the Binary State Control Instruction (also called "F29...F32767"). This also applies to the white z21, which has no physical LocoNet interface, but however has a virtual LocoNet stack inside.

For the structure of the OPC\_IMM\_PACKET see LocoNet Spec (also in "personal edition" for learning purposes). For the structure of the Binary State Control Instruction see NMRA S-9.2.1 Section "Feature Expansion Instruction".

### 9.4 LAN\_LOCONET\_DISPATCH\_ADDR

**From Z21 FW Version 1.20.**

Prepare a loco address for the LocoNet dispatch.

This message allows a LAN client to prepare a specific locomotive address for the LocoNet dispatch. This corresponds to a "DISPATCH\_PUT" and means that at the next "DISPATCH\_GET" (triggered by handset controller) the slot belonging to this loco address is reported back by Z21. If necessary, the Z21 automatically occupies a free slot for this purpose.

Request to Z21:

DataLen		Header		Data
0x06	0x00	0xA3	0x00	16 bits Loco address ( <b>little endian</b> )

Reply from Z21:

**Z21 FW Version < 1.22: none**

**Z21 FW Version ≥ 1.22:**

Z21 to Client:

DataLen		Header		Data
0x07	0x00	0xA3	0x00	16 bits Loco address ( <b>little endian</b> ) <b>Result 8 bit</b>

- Result 0**      The "DISPATCH\_PUT" for the given address failed.  
This can happen, for example, if the Z21 is operated as a LocoNet slave and the LocoNet master has rejected the dispatch request because this locomotive address is already assigned to another handset.
- >0      The "DISPATCH\_PUT" was executed successfully. The loco address can now be transferred to a handset controller (e.g. FRED). The value of Result corresponds to the current LocoNet slot number for the given loco address.

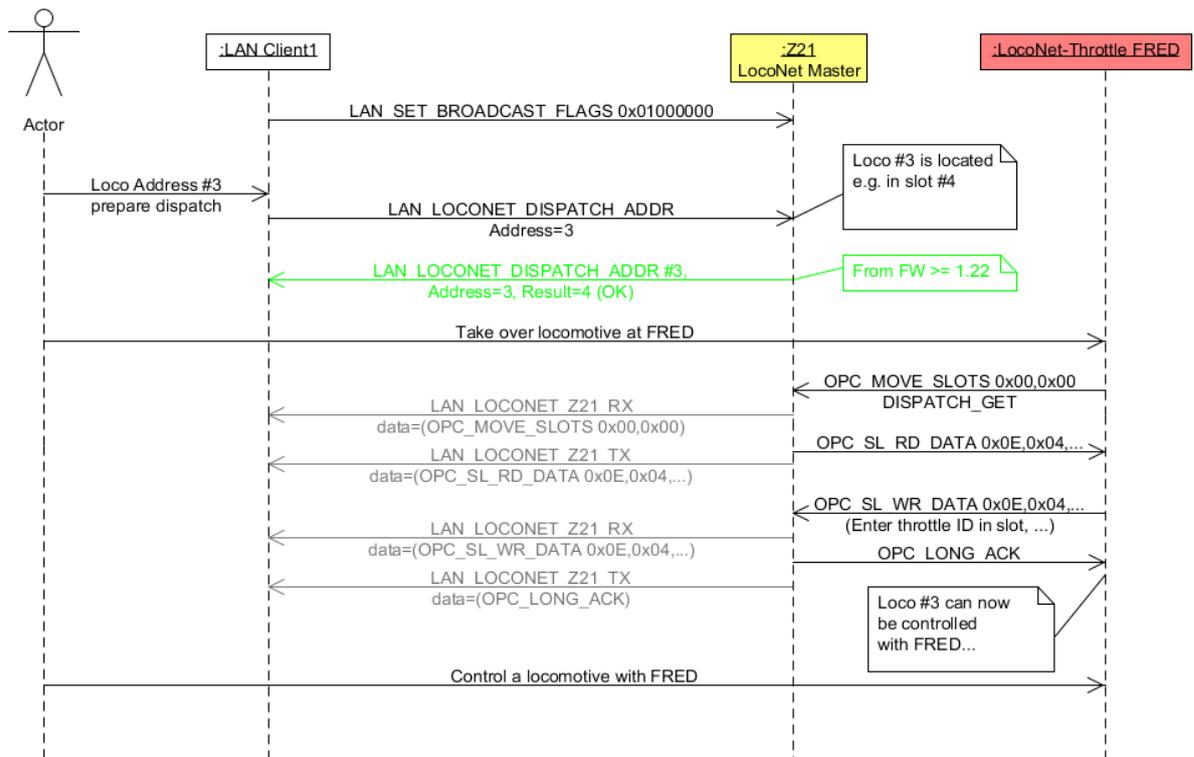


Figure 9 Example Sequence: LocoNet Dispatch per LAN-Client

## 9.5 LAN\_LOCONET\_DETECTOR

### From Z21 FW Version 1.22.

If LAN client application wants to support a LocoNet track occupancy detector, there are two ways. The first would be to receive the LocoNet packets via **9.1 LAN\_LOCONET\_Z21\_RX** and process the corresponding LocoNet messages directly. However, this requires an exact knowledge of the LocoNet protocol and it would produce a lot of network traffic.

Therefore the following alternative was created, with which you can **poll** the occupied status **as well as** be **asynchronously informed** about a change of the occupied status, without having to go into the depths of the LocoNet protocol.

**Information:** please note the following essential difference between the Roco Feedback Module 10787 on the R-BUS (see **7 Feedback – R-BUS**) and LocoNet Track Occupancy Detectors:

- 10787 is normally connected with mechanically operated switching contacts, which can be closed and reopened per axis of the train running over it.
- LocoNet track occupancy detectors are usually based on exact current measurement at the monitored track section or on advanced technologies (transponder, infrared, RailCom, ..) in order to reliably determine the occupancy state of the track. During normal operation, ideally only one message is generated when the occupied state changes.

The following command can be used to poll the status of one or more track occupancy detectors.

Request to Z21:

DataLen		Header		Data	
0x07	0x00	0xA4	0x00	Type 8 bit	16 bits report address ( <b>little endian</b> )

- |             |             |  |
|-------------|-------------|--|
| <b>Type</b> | <b>0x80</b> | Request via "Stationary Interrogate Request" (SIC) according to Digitrax procedure. This procedure also can be used for the occupancy detectors from Blücher-Elektronik. The parameter "report address" is 0 (not relevant).   |
|             | <b>0x81</b> | Request via so-called <b>report address</b> for Uhlenbrock occupancy detector. This report address can be configured by the user e.g. UB63320 via LNCV 17 in the occupancy detector. The default value there is 1017. With type 0x81, this report address is only used for polling and should <b>not be confused</b> with the <b>feedback address</b> .<br><b>Note:</b> At the LocoNet bus this query is implemented via turnout switching commands, therefore the value according to LocoNet has to be decremented by 1. Example:<br><b>0x07 0x00 0xA4 0x00 0x81 0xF8 0x03</b><br>means: "request status of all occupancy detectors with report address 1017 (Report address = 1017 = <b>0x03F8</b> +1 = 1016 + 1)" |
|             | <b>0x82</b> | <b>Status request for LISSY, from Z21 FW Version 1.23</b><br>On the other hand, for Uhlenbrock LISSY the report address corresponds to the feedback address however. The type of the subsequent feedback message(s) strongly depends on the configured operating mode of the LISSY receiver. In the LISSY manual you can find out more about the extensive setting options of the LISSY receiver.  |

Please note that in the case of a single request, several occupancy detectors may be addressed at the same time, and therefore multiple responses are to be expected. Depending on the manufacturer of the occupancy detector, the status of the same input can be also reported several times after one request.

Reply from Z21:

Z21 to Client:

DataLen		Header		Data		
0x07 + <i>n</i>	0x00	0xA4	0x00	Type 8 bit	Feedback address 16 bits (little endian)	Info[ <i>n</i> ]

This message is asynchronously reported to the client by the Z21 when the client

- has activated the corresponding broadcast, see **2.16** LAN\_SET\_BROADCASTFLAGS, Flag 0x08000000
- and the Z21 has received a corresponding message from a track occupancy detector **due to a status change on its input, or due to an explicit status-request (polling) by a LAN client** using the commands described above.

**Feedback address** Each input of an occupancy detector has its own feedback address, which can be configured by the user (e.g. for Uhlenbrock and Blücher via LNCV), and which describes the monitored block with a unique address.

**Info[*n*]** Byte-Array; content and length *n* depending on **Type**, see below

**Type**      **0x01** For occupancy detector types like Uhlenbrock 63320 or Blücher GBM16XL reporting only the status "occupied" and "free" (by using LocoNet OPC\_INPUT\_REP, X=1).

*n*=1

Status of the input belonging to the feedback address can be found in **Info[0]**:  
**Info[0]=0** ... sensor is **LOW** ("free")  
**Info[0]=1** ... sensor is **HIGH** ("occupied")

**0x02 Transponder Enters Block**  
**0x03 Transponder Exits Block**

For occupancy detectors such as Blücher GBM16XN etc. reporting also the information about the vehicle (e.g. locomotive address) inside the block to the command station (by using LocoNet OPC\_MULTI\_SENSE transponding encoding from Digitrax).

In addition to the feedback address, also a so-called transponder address is transmitted. The **transponder address** identifies the vehicle in the block. In the case of the GBM16XN, this is the **locomotive address** which was determined by the occupancy detector by using RailCom.

*n*=2

The transponder address is located in **Info[0]** und **Info[1]**, 16 Bit little endian:  
**Info[0]** ... transponder address low byte  
**Info[1]** ... transponder address high byte

Remark: due to lack of specification inside the LocoNet spec, the value ranges in OPC\_MULTI\_SENSE is not quite clear, which leaves the manufacturers of the occupancy detectors sometimes in the dark. Therefore in the case of GBM16XN the following must be observed according to our experience:

- You have to add +1 to the feedback address to get the feedback address configured in GBM16XN.
- Depending on the configuration of the GBM16XN, the direction of the vehicle on the track can also be coded in the bit under the mask 0x1000. Such a configuration is not recommended because this bit collides with the address space of long locomotive addresses!

**0x10 LISSY Loco address from Z21 FW 1.23.**

This message is sent to the Z21 LAN Client when an Uhlenbrock LISSY receiver reports a vehicle equipped with a LISSY transmitter and this LISSY receiver is configured to the "Transfer format (ÜF) Uhlenbrock" (LNCV 15=1). Furthermore, this message strongly depends on the configured operating mode (LNCV2, ...) of the LISSY receiver.

See also LISSY manual.

**n=3**

The Loco address is located in **Info[0]** und **Info[1]**, 16 Bit little endian:

**Info[0]** ... loco address low byte

**Info[1]** ... loco address high byte

Locomotives have a value range from 1..9999

Wagons have a value range from 10000 to 16382

**Info[2]** ... Additional info according to following bits: 0 **DIR1 DIR0** 0 **K3 K2 K1 K0**

**DIR1=0: DIR0** is to be ignored

**DIR1=1: DIR0=0** is forwards, **DIR0=1** is backwards

**K3..K0**: 4 bit "class information" stored in the LISSY sender.

Example Configuration for Lissy Receiver 68610:

LNCV	Value	Comment
2	98	optional module reset: sets all LNCV to 0, except LNCV 0 and 1 (address)
2	0	Basic function: readout locomotive data and direction information by using double sensor
15	1	Send using "Transfer format (ÜF) Uhlenbrock" onto LocoNet

**0x11 LISSY block status from Z21 FW 1.23.**

This message is sent to the Z21 LAN Client when an Uhlenbrock LISSY receiver sends a block occupancy status message using the "Transfer format (ÜF) Uhlenbrock". See also LISSY manual.

**n=1**

Status of the block belonging to the feedback address is in **Info[0]**:

**Info[0]=0** ... block is free

**Info[0]=1** ... block is occupied

Example Configuration for Lissy Receiver 68610:

LNCV	Value	Comment
2	98	optional module reset: sets all LNCV to 0, except LNCV 0 and 1 (address)
2	22	Automation function with block status message: Time-controlled waiting station
3	2	Automation active in both driving directions
4	3	Wait time 3 seconds
10	2	Block option: Block status change to "free" after 2 seconds
15	1	Send using "transfer format (ÜF) Uhlenbrock" onto LocoNet

**0x12 LISSY Speed from Z21 FW 1.23.**

This message is sent to the Z21 LAN Client when a Uhlenbrock LISSY receiver is configured for speed measurement.  
See also LISSY manual.

***n=2***

The speed is located in **Info[0]** and **Info[1]**, 16 bit little endian:

**Info[0]** ... speed low byte

**Info[1]** ... speed high byte

Example Configuration for Lissy Receiver 68610:

LNCV	Value	Comment
2	98	optional module reset: sets all LNCV to 0, except LNCV 0 and 1 (address)
2	0	Basic function: readout locomotive data and direction information by using double sensor
<b>14</b>	<b>15660</b>	<b>Velocity Scaling factor = 1566 (H0-scale) * 10mm (sensor distance)</b>
15	1	Send transfer format Uhlenbrock to LocoNet

Note: **Type** will be extended by further IDs in the future as required.

## 10 CAN

### 10.1 LAN\_CAN\_DETECTOR

#### Ab Z21 FW Version 1.30.

The Roco CAN occupancy detector 10808 is supported from FW version 1.30 on. The occupancy detector can be used by the LAN client in four different ways:

1. **R-BUS emulation:** the CAN detector is forwarded to the LAN client as R-BUS detector in the Z21 firmware. So the LAN client can use the CAN detector as described in Chapter 7 Feedback - R-BUS.
2. **LocoNet emulation:** the CAN detector is forwarded in the Z21 firmware as LocoNet detector to the LAN client. Thus the LAN client can use the CAN detector as described in chapter 9.5 *LAN\_LOCONET\_DETECTOR* (type 0x01 "occupied/free" and the locomotive address via type 0x02 and 0x03 "Transponder Enters Block, Transponder Exits Block").
3. **LISSY emulation:** The CAN detector is emulated in the Z21 firmware by LISSY/Marco messages. The LAN client can use the CAN detector as described in chapter 9.5 *LAN\_LOCONET\_DETECTOR* (type 0x10 "Locomotive address" and type 0x11 "block status").
4. Direct access by the command `LAN_CAN_DETECTOR` (see below).

The type of emulation can be configured via the Z21 Maintenance Tool. The factory setting is: **R-BUS emulation=on, LocoNet emulation=on, LISSY emulation=off.**

However, the fastest method, however, and the one that is most economic concerning memory and bandwidth, is direct access using the command **LAN\_CAN\_DETECTOR 0xC4**. This is particularly recommended when a large number of CAN occupancy detectors are used at the same time. With the following command, the status of the CAN occupancy detectors can be polled:

Request to Z21:

DataLen		Header		Data	
0x07	0x00	0xC4	0x00	Type 8 bit	CAN-NetworkID 16 bit (little endian)

**Type**            **0x00**    Request the CAN occupancy detector with the given CAN network ID. The CAN NetworkID **0xD000** means "all CAN detectors".  
 Example:  
**0x07 0x00 0xC4 0x00 0x00 0x00 0xD0**  
 means: "poll status of all CAN occupancy detectors"

Please note that with a single request several CAN occupancy detectors are addressed at the same time, and therefore multiple responses are to be expected. Depending on the configuration of the emulation, the status of one and the same input can also be reported several times.

Reply from Z21:

Z21 to Client:

DataLen		Header		Data					
0x0E	0x00	0xC4	0x00	<b>Nid</b> 16 bit	<b>Addr</b> 16 bit	<b>Port</b> 8 bit	<b>Type</b> 8 bit	<b>Value1</b> 16 bit	<b>Value2</b> 16 bit

This message is also reported to the client by the Z21 asynchronously when the client

- Has activated the corresponding broadcast, see **2.16** LAN\_SET\_BROADCASTFLAGS, Flag 0x00080000
- and the Z21 has received a corresponding message from the CAN detector, due to a **status change at its input**, OR due to an **explicit polling by a LAN client** using commands described above.

All 16 bit values are little endian coded.

<b>Nid</b>	Unchangeable CAN network ID of the occupancy detector.
<b>Addr</b>	Configurable module address of the occupancy detector. Each CAN occupancy detector has a module address which can be set by the user.
<b>Port</b>	Input pin number of the CAN occupancy detector (0 to 7)
<b>Type</b>	<p><b>0x01</b> <b>Occupancy status</b> of input (free, busy, overload)</p> <p><b>0x11</b> 1<sup>st</sup> and 2<sup>nd</sup> recognized <b>locomotive address</b> at the entrance</p> <p><b>0x12</b> 3<sup>rd</sup> and 4<sup>th</sup> recognized <b>locomotive address</b> at the entrance</p> <p>...</p> <p><b>0x1F</b> 29<sup>th</sup> and 30<sup>th</sup>. recognized <b>locomotive address</b> at the entrance</p>

The value of Value1 and Value2 depends on the type.

**If Type = 0x01 (occupied status):**

<b>Value1</b>	<b>0x0000</b>	<b>Free, without voltage</b>
	<b>0x0100</b>	<b>Free, with voltage</b>
	<b>0x1000</b>	<b>Occupied, without voltage</b>
	<b>0x1100</b>	<b>Occupied, with voltage</b>
	<b>0x1201</b>	<b>Occupied, Overload 1</b>
	<b>0x1202</b>	<b>Occupied, Overload 2</b>
	<b>0x1203</b>	<b>Occupied, Overload 3</b>

**If Type = 0x11 to 0x1F (RailCom Loco address):**

Type 0x11 to 0x1F form a list of locomotive addresses.

This vehicle list ends with the locomotive address=0.

<b>Value1</b>	First detected locomotive address in section incl. direction information. 0 = no locomotive address detected (e.g. with decoder not capable of RailCom, or no locomotive), resp. end of locomotive address list
<b>Value2</b>	Second detected locomotive address in section incl. direction information. 0 = no locomotive address detected, resp. end of locomotive address list

The direction information is coded in the most significant two bits of Value1 resp. Value2:

0 x	No direction detected
1 0	Vehicle has been placed forward on the track
1 1	Vehicle has been placed backwards on the track

The lower 14 bits contain the locomotive address.

## Appendix A – Command overview

### Client to Z21

Header	Parameter			Name
	X-Header	DB0	Parameter	
0x10	-			LAN_GET_SERIAL_NUMBER
0x18	-			LAN_GET_CODE
0x1A	-			LAN_GET_HWINFO
0x30	-			LAN_LOGOFF
0x40	0x21	0x21	-	LAN_X_GET_VERSION
0x40	0x21	0x24	-	LAN_X_GET_STATUS
0x40	0x21	0x80	-	LAN_X_SET_TRACK_POWER_OFF
0x40	0x21	0x81	-	LAN_X_SET_TRACK_POWER_ON
0x40	0x22	0x11	Register	LAN_X_DCC_READ_REGISTER
0x40	0x23	0x11	CV-Address	LAN_X_CV_READ
0x04	0x23	0x12	Register, Value	LAN_X_DCC_WRITE_REGISTER
0x40	0x24	0x12	CV-Address, Value	LAN_X_CV_WRITE
0x40	0x24	0xFF	Register, Value	LAN_X_MM_WRITE_BYTE
0x40	0x43		Turnout address	LAN_X_GET_TURNOUT_INFO
0x40	0x53		Turnout address, Switching cmd	LAN_X_SET_TURNOUT
0x40	0x80		-	LAN_X_SET_STOP
0x40	0xE3	0xF0	Loco address	LAN_X_GET_LOCO_INFO
0x40	0xE4	0x1s	Loco address, Speed	LAN_X_SET_LOCO_DRIVE
0x40	0xE4	0xF8	Loco address, Function	LAN_X_SET_LOCO_FUNCTION
0x40	0xE6	0x30	POM-Param, Option 0xEC	LAN_X_CV_POM_WRITE_BYTE
0x40	0xE6	0x30	POM-Param, Option 0xE8	LAN_X_CV_POM_WRITE_BIT
0x40	0xE6	0x30	POM-Param, Option 0xE4	LAN_X_CV_POM_READ_BYTE
0x40	0xE6	0x31	POM-Param, Option 0xEC	LAN_X_CV_POM_ACCESSORY_WRITE_BYTE
0x40	0xE6	0x31	POM-Param, Option 0xE8	LAN_X_CV_POM_ACCESSORY_WRITE_BIT
0x40	0xE6	0x31	POM-Param, Option 0xE4	LAN_X_CV_POM_ACCESSORY_READ_BYTE
0x40	0xF1	0x0A	-	LAN_X_GET_FIRMWARE_VERSION
0x50	Broadcast-Flags			LAN_SET_BROADCASTFLAGS
0x51	-			LAN_GET_BROADCASTFLAGS
0x60	Loco address			LAN_GET_LOCOMODE
0x61	Loco address, Mode			LAN_SET_LOCOMODE
0x70	Accessory decoder address			LAN_GET_TURNOUTMODE
0x71	Accessory decoder address, Mode			LAN_SET_TURNOUTMODE
0x81	Group Index			LAN_RMBUS_GETDATA
0x82	Address			LAN_RMBUS_PROGRAMMODULE
0x85	-			LAN_SYSTEMSTATE_GETDATA
0x89	Address			LAN_RAILCOM_GETDATA
0xA2	LocoNet message			LAN_LOCONET_FROM_LAN
0xA3	Loco address			LAN_LOCONET_DISPATCH_ADDR
0xA4	Type, Report address			LAN_LOCONET_DETECTOR
0xC4	Type, NId			LAN_CAN_DETECTOR

Table 1 : Messages from Client to Z21

**Z21 to Client**

Header	Data			Name
	X-Header	DB0	Data	
0x10	Serialnumber			Reply to LAN_GET_SERIAL_NUMBER
0x18	Code			Reply to LAN_GET_CODE
0x1A	HWType, FW Version (BCD)			Reply to LAN_GET_HWINFO
0x40	0x43	Turnout information		LAN_X_TURNOUT_INFO
0x40	0x61	0x00	-	LAN_X_BC_TRACK_POWER_OFF
0x40	0x61	0x01	-	LAN_X_BC_TRACK_POWER_ON
0x40	0x61	0x02	-	LAN_X_BC_PROGRAMMING_MODE
0x40	0x61	0x08	-	LAN_X_BC_TRACK_SHORT_CIRCUIT
0x40	0x61	0x12	-	LAN_X_CV_NACK_SC
0x40	0x61	0x13	-	LAN_X_CV_NACK
0x40	0x61	0x82	-	LAN_X_UNKNOWN_COMMAND
0x40	0x62	0x22	Status	LAN_X_STATUS_CHANGED
0x40	0x63	0x21	XBus Version, ID	Reply to LAN_X_GET_VERSION
0x40	0x64	0x14	CV-Result	LAN_X_CV_RESULT
0x40	0x81	-		LAN_X_BC_STOPPED
0x40	0xEF	Loco information		LAN_X_LOCO_INFO
0x40	0xF3	0x0A	Version (BCD)	Reply to LAN_X_GET_FIRMWARE_VERSION
0x51	Broadcast-Flags			Reply to LAN_GET_BROADCASTFLAGS
0x60	Loco address, Mode			Reply to LAN_GET_LOCOMODE
0x70	Accessory decoder address			Reply to LAN_GET_TURNOUTMODE
0x80	Group index, Feedback status			LAN_RMBUS_DATACHANGED
0x84	SystemState			LAN_SYSTEMSTATE_DATACHANGED
0x88	RailComData			LAN_RAILCOM_DATACHANGED
0xA0	LocoNet message			LAN_LOCONET_Z21_RX
0xA1	LocoNet message			LAN_LOCONET_Z21_TX
0xA2	LocoNet message			LAN_LOCONET_FROM_LAN
0xA3	Loco address, Result			LAN_LOCONET_DISPATCH_ADDR
0xA4	Type, Feedback address, Info			LAN_LOCONET_DETECTOR
0xC4	Occupancy message			LAN_CAN_DETECTOR

**Table 2 : Messages from Z21 to Clients**

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