standard	RCN-217	RailCommunity
output July 27, 2025	**RailCom** **DCC feedback protocol**	RailCommunity – Association the manufacturer of digital Model Railway Products eV

Contents

1 General

1.1 Purpose of the standard

This standard describes the transmission of data from the decoder over the track to a receiver, i.e., in the opposite direction to the control protocols. The transmission method described here, together with the protocol used, is called
RailCom.

"RailCom" is a German trademark registered in the name of Lenz Elektronik for Class 9 "Electronic Controls" under number 301 16 303, and a trademark registered in the USA for Classes 21, 23, 26, 36, and 38 "Electronic Controls for Model Railways" under Reg. No. 2,746,080. European Patent 1 380 326 B1 has been revoked. RailCom is therefore freely usable, subject to the trademarks.

This specification applies exclusively to the use of RailCom within the DCC data format (protocol). The use of RailCom within other data formats is not permitted.

1.2 Requirements

To comply with this standard, all technical values and protocols defined in this standard must be observed. Tables 5 to 7 define which messages a decoder must support at a minimum.

1.3 Explanations

• A DCC data packet is a defined sequence of bits that is used as a track signal in [RCN-210] are described.

• Bytes are groups of eight bits each. • Each bit in the byte has a value that depends on its position; the first
The bit sent, the leftmost bit in the diagram, has the highest value and is called the MSB (most significant bit). The bits of a byte are numbered from left to right, starting with 7 and descending to 0. The last bit sent, the rightmost bit in the diagram, is called the LSB (least significant bit).

• “XF#” refers to the binary state control instructions according to [RCN-212] Section 2.3.5.
• The following symbols are used to indicate the meaning of a bit:

0 Bit value 0
1 bit value 1
A address bit
D data bit
G speed
L Load
P Location information (position)
R direction bit
S sequence number
T Type of location information
X Subindex

The characters used in the DCC commands are not listed again here.

The bit combinations for DCC shown in the boxes in this standard are purely informative and are not normative. Only the specified RCNs apply.

The commands from the command station to the decoder (ÿ) are written without the addressing data. Addressing is done according to the DCC standard.

(ÿ) indicates the RailCom data sent from the decoder to the central unit.

Unless otherwise specified, values always refer to an 8-bit field. Binary values are marked according to the list above. Hexadecimal values are marked with a leading 0x.

2 Physical Layer

This chapter describes the physical layer of RailCom.

2.1 General

The flow of information in the DCC system normally occurs from the central unit (booster) via the track to the decoders. For the reverse transmission direction, this power and data flow must be interrupted. This is achieved by the boosters, which create a so-called RailCom cutout at the end of each DCC packet by disconnecting and short-circuiting the two track lines from the power supply.

This functional group within the booster is called a "cutout device." Such a cutout device could also be implemented as a separate unit outside the booster.
The actual data transmission takes place via a current loop. The decoder must provide the necessary current from its internal buffer. Figure 1 shows the arrangement of the booster, detector, and decoder during the RailCom cutout.

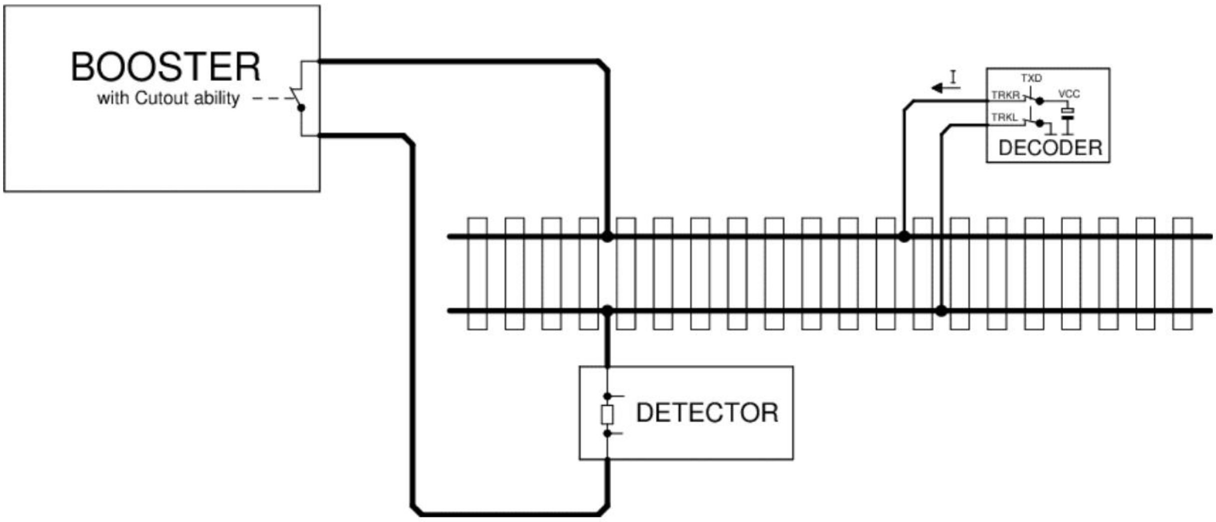

Figure 1: RailCom schematic diagram

The voltage drop across the cutout device must not exceed 10mV at a maximum of 34mA during cutout.

2.2 RailCom – transmitter in the decoder

To transmit a '0', the decoder must supply a current I of 30 +4/-6 mA, with a voltage drop on the track of up to 2.2 V. If high-current RailCom is enabled in CV28, the current is 60 +8/-12 mA, also with a voltage drop on the track of up to 2.2 V. For a '1', the current I may not exceed ± 0.1 mA. The current source

The decoder's power supply must be protected against unexpected external voltage on the track during cutout. Figure 2 shows a possible hardware implementation.

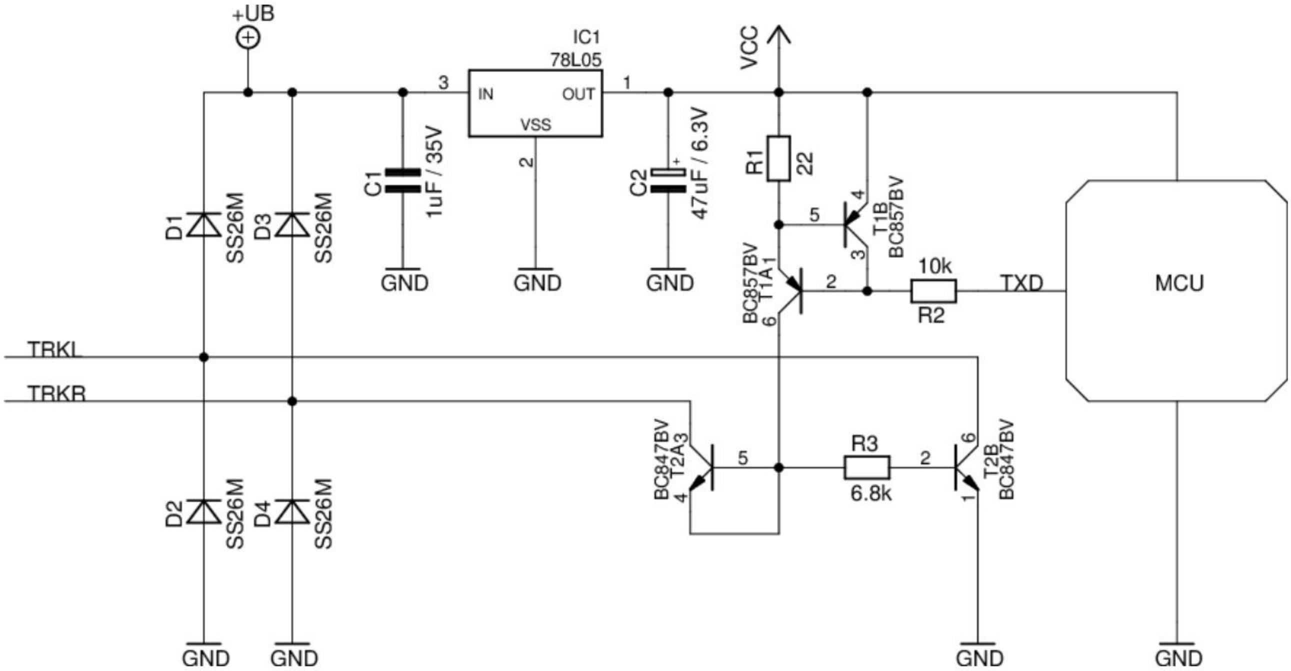

Figure 2: Symbolic representation of the RailCom decoder hardware

Explanation of the circuit diagram:
The RailCom component consists only of resistors R1 to R3 and transistors T1A to T2B. T1A and T1B form a current source, while T2A is connected as a diode and protects the current source from positive voltages higher than Vcc.
All other parts of the circuit are part of the normal hardware required for the decoder.
Note the extremely low hardware requirements for the RailCom transmitter.

It is recommended that the power supply be connected so that the positive pole is on the right rail, forward in the direction of travel. This allows the vehicle's direction on the track to be detected. However, there are situations where this recommendation cannot be followed. Therefore, ID 3 has been added to channel 1 (section 5.2.2).

Due to its principle, direction detection only works in a two-rail, two-rail system. In a three-rail, two-rail system ("Märklin") or a three-rail, three-rail system ("Trix-Express"), the rerailing direction cannot be detected via the polarity of the RailCom or track signal. Therefore, neither the recommendation here nor ID 3 in channel 1 can be used.

2.3 The RailCom Detector

A detector must interpret a current greater than 10 mA during the middle 50% of the bit time as '0', and a current less than 6 mA during the middle 50% of the bit time as '1'. The voltage drop across the detector must not exceed 200 mV at a maximum current of 34 mA during cutout. Figure 3 shows a possible hardware implementation.

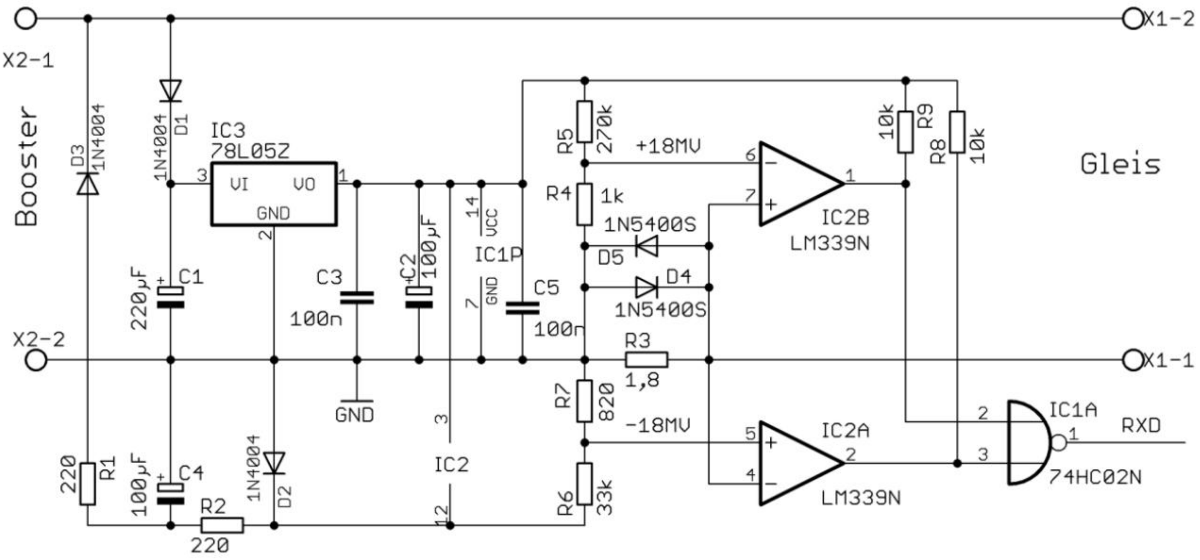

Figure 3: Example of a simple RailCom Detector hardware

A maximum of two detectors (including the global detector) may be used in series. The local detector should include a connection for external evaluation of track occupancy. If this is not the case, externally used occupancy detectors must be specified for RailCom. Explanation:

> These circuits (transmitter and detector) were tested on large club layouts up to a distance of 100 meters. This distance was bridged without any problems. 5-ohm loads, not isolated from the track by bridge rectifiers, are permitted. These loads are connected in parallel with the detector's measuring resistor.
> The value of 5 Ohms corresponds to a current of 3A at a track voltage of 15V.
> Incandescent lamps (PTC thermistors) must always be operated via a fast bridge rectifier (< 500 ns).

2.4 Timing

Up to 8 bytes of data can be transmitted in a cutout. Each transmitted byte begins with a start bit ('0') followed by the 8 data bits (least significant bit first) and ends with a stop bit ('1'). The transmission rate is 250 kbit/s ±2%. The rise time (10% ÿ 90%) and fall time (90% ÿ 10%) must not exceed 0.5 µs.

The RailCom cutout is divided into two channels. Channel 1 can transmit 2 bytes, and channel 2 can transmit up to 6 bytes. Figure 4 shows the timing diagram. All times are referenced to the zero crossing of the last edge of the packet end bit.

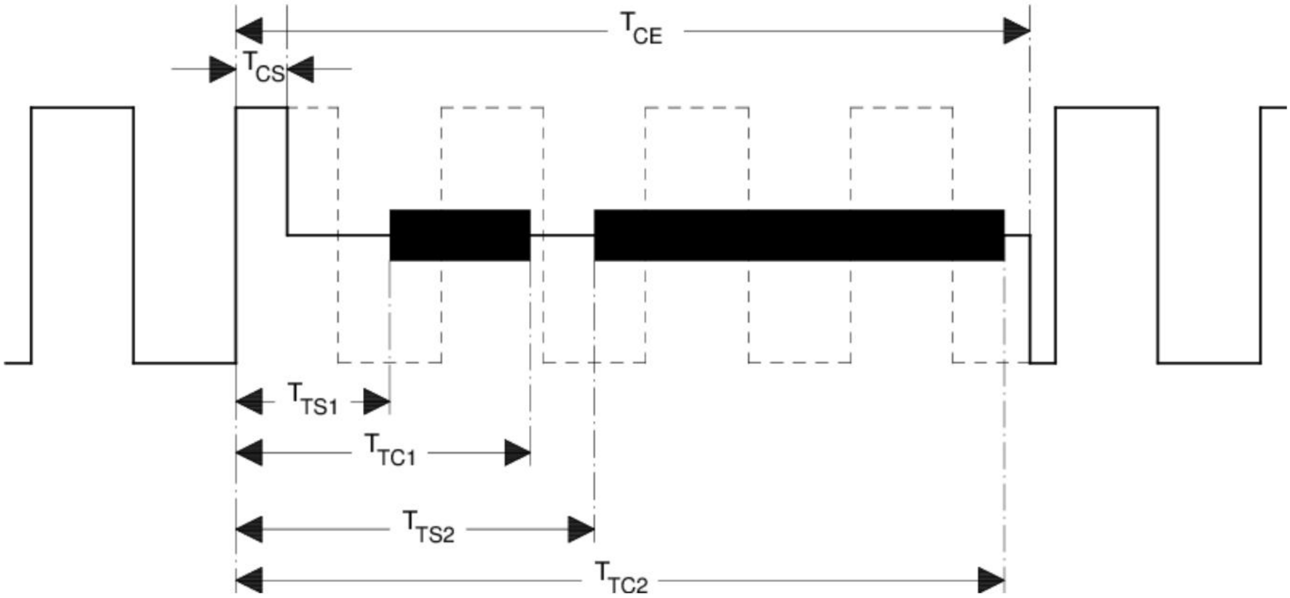

Figure 4: RailCom Timing

parameter	**Name Min**		**Max**
Cutout Start	TCS	26µs	32µs
Cutout End	TCE	454µs	488µs
Start Channel 1	TTS1	80µs *)	
End Channel 1	TTC1		177µs
Start Channel 2	TTS2	193µs	
End Channel 2	TTC2		454µs

Table 1: Timing parameters

*) Detector should be ready to receive at 75 µs for channel 1.

Remark:

The figure above shows the RailCom timing with "1" bits of 2*58µs (the nominal value of the DCC "1" bit). With shorter "1" bits, it is possible that the cutout extends into the 5th "1" bit.
However, this is not a problem, since a central unit according to [RCN-211] has at least 4 + 12 = 16 must send synchronous bits (not counting the packet end bit of the previous DCC pa~~cket),~~ so that the decoder sees enough synchronous bits (at least 12 synchronous bits must be sent, 10 are required for the decoder to recognize the packet).

A cutout time of approximately 450µs must not affect the function of a decoder that does not support RailCom, since power interruptions of up to 20ms have been demonstrated on a real model railway layout, meaning that a decoder should be able to handle at least one power interruption of this magnitude.

2.5 Data backup

Data transmission is secured using 4 out of 8 coding, meaning each transmitted byte contains 4 '1' and 4 '0' bits (Hamming weight 4). If this ratio is violated, a transmission error occurs.

There are 70 different bit combinations within a byte, each with a Hamming weight of 4. Of these, 64 are used to transmit six payload bits; of the remaining six, three are used for short special messages: two ACKs and two NACKs. The remaining three combinations are currently unused.

A net 12 bit payload can be transmitted in channel 1 and up to 36 bit payload in channel 2.

The possible encodings:

Value	code	Value	Code	Value	Code	Value	Code
0x00	10101100	0x10	10110010	0x20	01010110	0x30	11000110
0x01	10101010	0x11	10110100	0x21	01001110	0x31	11001100
0x02	10101001	0x12	10111000	0x22	01001101	0x32	01111000
0x03	10100101	0x13	01110100	0x23	01001011	0x33	00010111
0x04	10100011	0x14	01110010	0x24	01000111	0x34	00011011
0x05	10100110	0x15	01101100	0x25	01110001	0x35	00011101
0x06	10011100	0x16	01101010	0x26	11101000	0x36	00011110
0x07	10011010	0x17	01101001	0x27	11100100	0x37	00101110
0x08	10011001	0x18	01100101	0x28	11100010	0x38	00110110
0x09	10010101	0x19	01100011	0x29	11010001	0x39	00111010
0x0A	10010011	0x1A	01100110	0x2A	11001001	0x3A	00100111
0x0B	10010110	0x1B	01011100	0x2B	11000101	0x3B	00101011
0x0C	10001110	0x1C	01011010	0x2C	11011000	0x3C	00101101
0x0D	10001101	0x1D	01011001	0x2D	11010100	0x3D	00110101
0x0E	10001011	0x1E	01010101	0x2E	11010010	0x3E	00111001
0x0F	10110001	0x1F	01010011	0x2F	11001010	0x3F	00110011
ACK	00001111	"Command understood and will be executed" or "YES"					
ACK	11110000	"Command understood and will be executed" or "YES"					
reserved	11100001						
reserved	11000011						
reserved	10000111						
NACK	00111100	"Command or CV is not supported" – optional					

Table 2: Codings in the 4 out of 8 code

Explanation of NACK:

This optional response can identify an unsupported command. Detection of an unsupported command is based exclusively on the first command byte. With POM (independently of the response to unimplemented commands), a NACK can also be sent to identify a nonexistent CV. To prevent the POM command from being mistakenly interpreted as unsupported, a NACK may not be sent as the first response to a POM command. This means that when accessing a nonexistent CV, the response is first an ACK and then a NACK. ACK and NACK can be sent together on the same channel 2.

3 Packet Layer

This chapter describes the structure of RailCom packages.

RailCom packets (hereinafter referred to as datagrams) have a length of 6, 12, 18, 24, or 36 payload bits. Only a 12-bit datagram can be transmitted on channel 1. Any combination of datagrams with a maximum total length of 36 bits can be transmitted on channel 2.

Optionally, the data channel can be filled to 36 bits with ACK.

Datagrams (except ACK and NACK) begin, unless otherwise stated, with a 4-bit Identifier, followed by 8, 14, 20 or 32 bit payload, which is transmitted as follows:

Datagram	**Bytes**
12 bits	ID[3-0]D[7-6]+D[5-0]
18 bits	ID[3-0]D[13-12]+D[11-6]+D[5-0]
24 bits	ID[3-0]D[19-18]+D[17-12]+D[11-6] +D[5-0]
36 bits	ID[3-0]D[31-30]+D[29-24]+D[23-18]+D[17-12]+D[11-6] +D[5-0]

Table 3: Datagram structure

The length of the datagram is determined by the identifier (see chapters 3.1 and 3.2).

For automatic decoder registration, the two data channels can be combined (channel bundling). The timing of the two channels remains unchanged, but only one data block with a total of 48 bits – including an identifier depending on the context – is transmitted. The structure of this data block is defined in [RCN-218].

Mobile decoders (vehicle decoders) and stationary decoders (accessory decoders) have different feedback requirements. Accordingly, the channels are used differently for both decoder types. The meaning of the datagrams therefore depends on the address of the preceding DCC packet. Accordingly, the following RailCom command types, MOB (mobile) and STAT (stationary), are differentiated based on the DCC address ranges as defined in [RCN-211] Section 3:

DCC address data in		Channel 1	DCC or RailCom command type
1st byte	2nd byte		
0		no	Vehicle decoder broadcast
1-127		ID 1, ID 2	MOB (vehicle decoder) Short address
128-191		SRQ	STAT (accessory decoder) – no identifier!
192-231	ADR low	ID 1, ID 2	MOB (vehicle decoder) Long address The long address 0 is also used as the programming address. (Section 5.2.4)
232-252		no	Reserved
253		no	Used for data transmission according to the NMRA specification in [S-9.2.1.1]. Addressing is done via the DCC address in a packed format.
254		Channel bundling	Used for automatic registration according to [RCN-218] – Identifier context-dependent! For addressed commands, addressing is done via unique ID.
255		ID14, ID 15 at RailCom-Plus®	255 is the address of the idle packet (0xFF - 0x00 - 0xFF) A first data byte not equal to 0 indicates the use within the framework of RailComPlus®. In any case, the packet consists of more than 3 bytes.

Table 4: DCC address ranges for command types

Decoders may not send feedback to the idle packet or service mode packets. Only the decoder addressed by the DCC packet may send on channel 2. To enable feedback on channel 1 as long as no DCC locomotive address is addressed, it is recommended to address DCC locomotive address 10239 alternately with the idle packet.

Following a command to address 254 either for automatic registration with DCC-A according to [RCN-218] or [S-9.2.1.1], channels 1 and 2 are bundled and context-dependent identifiers are used. The responses following commands to addresses 253 and 255 are defined in the NMRA standard [S-9.2.1.1] or the RailComPlus® standard.
Specification defined.

3.1 RailCom command type MOB

Channel 1 is used by mobile vehicle decoders for rapid localization on the layout (see app:adr). To do this, they must transmit their DCC address after each DCC packet addressed to a vehicle decoder (labeled MOB in Table 4), which is then received by local detectors on the layout. Programming mode packets are excluded from this rule from the moment the decoder detects programming mode. Transmission after each DCC packet addressed to a vehicle decoder (short address 1..127, long address 1..10239) is required to prevent parts of different addresses from being mistakenly combined into an incorrect, nonexistent address when multiple transmitters are in the section.

Channel 2 may only be used by the addressed decoder and is used to transmit decoder information.
An addressed decoder must always send an acknowledgement (ACK if necessary) on channel 2 to confirm error-free reception of the DCC packet.
A feedback signal on channel 2 indicates that the decoder has received the command without errors, but not that the decoder has accepted and executed the command.

The following identifiers (datagrams) are defined for vehicle decoders, whereby all IDs not listed are to be considered reserved.

ID	Channel 1	remark
1	app:adr_high	mandatory
2	app:adr_low	Mandatory
3	app:info1	optional, enabled via CV 28 bit 3.
14	RailComPlus	No longer available for the RailCommunity.
15	RailComPlus	No longer available for the RailCommunity.

Table 5: Command type MOB Identifier (datagrams) in channel 1

ID	Channel 2	length	remark	Command-related
0	app:pom	12 bits	Mandatory, 1 byte	yes, POM RCN-214
1	app:adr_high	12 bits	optional for Rerail search	Yes, Rerail search XF2
2	app:adr_low	12 bits	optional for Rerail search	Yes, Rerail search XF2
3	app:ext	18 bits	optional	Yes, Location information XF1
4	app:info	36 bits	reserved for current Driving information	no
7	app:dyn	18 bit (if necessary twice)	optional	no[1]
8	app:xpom	36 bits	optional	yes, XPOM RCN-214
9	app:xpom	36 bits	optional	yes, XPOM RCN-214
10	app:xpom	36 bits	optional	yes, XPOM RCN-214
11	app:xpom	36 bits	optional	yes, XPOM RCN-214
12	app:CV-auto	36 Bit	Automatic transfer of CVs	no
13	app:block	36 bits	optional see [TN-217]	no
14	app:time	12 bits	optional for Rerail search	Yes, Rerail search XF2

Table 6: Command type MOB Identifier (datagrams) in channel 2

[1] So far, no command has been defined to request a specific DV. However, this is certainly possible to save IDs and could be implemented in the future.

"mandatory" full implementation means either full
"optional" implementation or: partial implementation with the conditions stated under 4.1
"Command-related": if "yes", the messages in channel 2 may only follow a corresponding command; if "no", they may follow any command to the decoder. These non-command-related responses are also considered ACKs.

> Remark:
> Older decoders used various identifiers during a test phase, which are now marked as "reserved." Newer decoders must have the RailCom version number entered in a special CV (see the "RailCom CVs" section). This can be used to distinguish them.
>
> Older decoders without a version number should be updated.

If multiple datagrams are sent on channel 2, they must be sent in the following ID order: 1 2 0 3 4 7 8 9 10 11 13 14 5 6 15 12. This is the order in which the IDs were defined. This allows older detectors to evaluate the datagrams they know. If an older datagram follows a newer one, the older detector cannot evaluate any datagram because it does not know the length of the first, newer datagram. An ACK or NACK must not be the leading datagram, because after an ACK or NACK, all data can be ignored.

3.2 RailCom command type STAT

Accessory decoders use channel 1 to report service requests (see app:srq). They can transmit their identity (12-bit address) (12-bit value without identifier) after each DCC packet addressed to an accessory decoder (labeled STAT in Table 4) (not when addressing via decoder ID). If multiple decoders report simultaneously, a search must be initiated.

The service request requirements are optional.

Channel 2 may only be used by the addressed decoder and is used to transmit decoder information. An addressed decoder must always send an acknowledgement (ACK if necessary) on channel 2 to confirm error-free reception of the DCC packet.

A feedback signal on channel 2 indicates that the decoder has received the command without errors, but not that the decoder has accepted and executed the command.

The following identifiers (datagrams) in channel 2 are defined for accessory decoders, whereby all IDs not listed are to be considered reserved:

ID	Channel 2	length	remark	Command-related
0	app:pom	12 bits	optional	yes, POM RCN-214
3	app:stat4	36 bits	optional	no
4	app:stat1	12 bits	mandatory	no
5	app:time	12 bits	optional	no
6	app:error	12 bits	mandatory	no
7	app:dyn	18 bit (if necessary twice)	optional	no[2]
8	app:xpom (old: stat2)	36 bits	optional	no
9	app:xpom	36 bits	optional	no
10	app:xpom	36 bits	optional	no
11	app:xpom	36 bits	optional	no
12	app: Test Feature ID	variable	optional	n/a
13	app:block	36 bits	optional	(not yet defined)

Table 7: Command type STAT Identifier (datagrams) in channel 2

"mandatory" ÿ means full implementation "optional" ÿ either full implementation or partial implementation with the conditions stated under 4.1

"Command-related" if "yes" means that the messages in channel 2 may only follow a corresponding command; if "no" means that they may follow any command to the decoder. These non-command-related responses are also considered ACKs.

4 RailCom CVs and DCC commands

4.1 System requirements

This RailCom specification is designed to be backward compatible, meaning that decoders that are not RailCom capable can continue to be operated and command stations that are not RailCom capable can continue to control decoders that are RailCom capable.

Controlling analogue vehicles (locomotives without decoder) using the extended "0" (stretched zero) is not allowed.

Decoders with RailCom implementation must support the following responses: ACK, vehicle decoders additionally app:adr_high and app:adr_low in channel 1 and app:pom in channel 2, accessory decoders additionally app:stat1 and app:fehler.

The decoder must respond to each vehicle or turnout address in channel 2 of the blanking interval (see applications). The decoder must not respond if it has not been addressed or if the command was sent to broadcast address 0.

[2] See footnote 2 in Table 6

4.2 CVs

All CVs presented here are for information purposes only. The specifications in [RCN-225] are binding.

4.2.1 CV28 RailCom configuration

Bit	function	
0	Channel 1 for address broadcast (section 5.2)	1 = enabled, 0 = disabled 1
1	Channel 2 for data and acknowledge 2	= enabled, 0 = disabled
	Channel 1 automatically switch off (section 5.2.1)	1 = enabled, 0 = disabled
3	Transmit ID 3 in channel 1 (section 5.2.2)	1 = enabled, 0 = disabled
4	Programming address 0000 (long address 0) (Section 5.2.4)	1 = enabled, 0 = disabled
5	reserved	
6	Release of high-current RailCom (Section 2.2)	1 = enabled, 0 = disabled
7	Release automatic login	1 = enabled, 0 = disabled

Table 8 RailCom configuration

Bits 0, 2 and 3 only apply to vehicle decoders and not to accessory decoders.

To be compatible with the previous behavior, CV28 bit 2 should be set to 0 when a decoder is delivered. When a decoder is delivered, the value of bit 0 should be 1 for vehicle decoders and 0 for accessory decoders, and the value of bit 1 should be 1 for all decoders. Channel 1 is always enabled for automatic registration via address 254 according to [RCN-218].

4.2.2 CV29

Use according to [RCN-225].

4.2.3 CV31, CV32

Use as pointer according to [RCN-225].

4.2.4 RailCom Block

CV31 = 0 and CV32 = 255 address a block of 256 CVs that are used for RailCom-Applications are documented according to the following table:

byte		z/o	
0-1	Manufacturer ID **assignment** (according to NMRA [S-9.2.2 Appendix A], little endian). This means that byte 0 corresponds to CV 8 or, in the case of a long manufacturer ID, CV 108, and byte 1 corresponds to CV 107.	z R	
4-7	Product ID (manufacturer-specific product identifier to distinguish between individual products. Little Endian)	o R	

8-11	MUN (Manufacturer Unique Number. Little Endian) 4-byte serial number for all devices of a manufacturer.	o R	
12-15	Production date (number of seconds since January 1, 2000, Little Endian, Unsigned)	o R	
16-63	Manufacturer-specific assignment	o R/W	
64-127	possible Dynamic variables according to APP DYN, Section 5.4, Table 12, Where the range from CV72 = DV 8 to CV83 = DV 19 corresponds to containers 1 to 12. Other DVs can be reset by writing the CV if necessary.	o R/W	
128	RailCom version number "before point" , binary	z R	
129	RailCom version number "after dot", binary	z R	
130	feature number for test feature ID (see 5.7)	o R	
131	reserved		
132	specific consumption, container 1	o R/W	
133	specific consumption, container 2	o R/W	
134	specific consumption, container 3	o R/W	
135	specific consumption, container 4	o R/W	
136	specific consumption, container 5	o R/W	
137	specific consumption, container 6	o R/W	
138	specific consumption, container 7	o R/W	
139	specific consumption, container 8	o R/W	
140	specific consumption, container 9	o R/W	
141	specific consumption, container 10	o R/W	
142	specific consumption, container 11	o R/W	
143	specific consumption, container 12	o R/W	
144	Fill level of all containers (0... 100), a write command in this CV sets the contents of all containers to the specified value.	o W	
145	Tacho scaling in the central office, Value times 2 = maximum speed in km/h	o R/W	
146-255	reserved		

Table 9: Occupancy Block 255

z = Mandatory, o = Optional, R = Read, W = Write

4.3 DCC commands

The expanded functionality provided by RailCom also requires additional DCC commands. These include:

4.3.1 Additional function commands

RailCom provides additional functionality such as search functions, rerail search, etc. (see also section "Applications (Application/APP) Layer for

Vehicle decoder"). For this purpose, the short form binary state control commands according to [RCN-212] section 2.3.5 are used.

Operating command: Binary state control as RailCom command	
ÿ Short bi	nary state control command according to ([RCN-212]) section 2.3.5 **1101-1101 DLLL-LLLL**

These commands are referred to in this standard as XF1 to 127.

Of these commands, the first 28 in [RCN-212] are reserved for special applications such as RailCom. The first 15 commands are intended for RailCom.

XF = Fun	**ction:**
1	Request location information according to section 5.3.1
2	Rerail search
3	Output of all CVs with CV-Auto ID 12
4 - 15	reserved

Table 10: Function numbers

4.3.2 Advanced programming commands

The [RCN-214] also defines the configuration variable access command - short form for programming CVs in Section 3. This also allows writing two fixed CV pairs:

KKKK = **0100** = Writing CV17 (first data byte) and CV18 (second data byte) (Extended address) at the same time, and set bit 5 in CV29.

Feedback is sent to the old address via two consecutive datagrams with ID 0: first the first data byte, followed by the second data byte. Both datagrams must be sent on the same channel 2, i.e., 12-bit datagram + 12-bit datagram.

Operating command: POM	
ÿ	CV access write of CV17 and CV18 according to [RCN-214] section 3 **1111-0100**
ÿ Channe	2: **0000** (ID 0) **DDDD-DDDD** + **0000** (ID 0) **DDDD-DDDD** with **D** = CV data, first CV17, then CV18

KKKK = **0101** = Writing CV31 (first data byte) and CV32 (second data byte) (Pointer value for extended range, high byte (31) and low byte (32)).

Feedback is provided via two consecutive datagrams with ID 0: first the first data byte, followed by the second data byte. Both datagrams must be sent on the same channel 2, i.e., 12-bit datagram + 12-bit datagram.

Operating command: POM	
ÿ	CV access write of CV31 and CV32 according to [RCN-214] section 3 **1111-0101**
ÿ Channel	2: **0000** (ID 0) **DDDD-DDDD** + **0000** (ID 0) **DDDD-DDDD** with **D** = CV data, first CV31, then CV32

4.3.3 NOP for accessory decoders

Accessory decoders report after a switching command if they want to communicate something to the central unit (SRQ).

Typically, switching commands are sent only sporadically, so accessory decoders might only make themselves known just as rarely. Therefore, the NOP command is defined in [RCN-213] Section 2.5. This command is sent regularly but initially does nothing except allow accessory decoders to send an SRQ.

This must be used by all non-RailCom capable simple and extended accessory decoders recognized as invalid and thus ignored. It serves, on the one hand, to enable accessory decoders to send an SRQ in the subsequent blanking interval. On the other hand, it also allows a search for the decoders involved in the event that multiple decoders report an SRQ simultaneously.

This is achieved by transmitting an accessory decoder address with the NOP. Only those decoders whose addresses are less than or equal to the one contained in the NOP respond. This allows for successive approximation of the decoder with the lower address to be located and operated. The search is repeated until no more decoders respond.

Operating command: NOP	
ÿ NOP for	accessory decoders according to [RCN-213] section 2.5 **10AA-AAAA 0AAA-1AAT**

For regular polling of all accessory decoders, the central unit sends a NOP with the highest possible address so that all decoders are addressed.

As long as only one decoder responds with an SRQ, the NOP with the highest address can remain. Only when multiple decoders respond simultaneously does the central unit need to initiate a search by appropriately varying the address contained in the NOP.

A RailCom-capable command station must send a NOP command at specific intervals to query the accessory decoders. The time interval between two NOPs is a compromise between bandwidth limitations for the DCC signal and response time to SRQ messages. An interval of approximately 0.5 seconds is recommended.

When searching for multiple messages, the NOPs used for the search must of course be sent one after the other as quickly as possible.

5 Applications (Application/APP) Layer for Vehicle decoder

The following sections describe the commands for the RailCom functionality for vehicle decoders with the address ranges marked as MOB in Table 4.

5.1 POM (ID 0)

POM stands for "Programming On the Main," meaning programming on the track for operation. It is used to read and write configuration variables in operating mode according to [RCN-214] Section 2. These commands are responded to on channel 2 with a 12-bit datagram with ID 0 = **0000** and 8 data bits. The data bits contain the value of the CV.

Operating command: POM	
ÿ	Access to bytes or bits according to [RCN-214] Section 2 **1110-KKVV VVVV-VVVV DDDD-DDDD** **1110-10VV VVVV-VVVV 111K-DBBB**
ÿ	Channel 2: **0000** (ID 0) **DDDD-DDDD** with **D** = CV data

5.1.1 Byte Reading

Operation command: POM byte read	
ÿ	Byte reading according to [RCN-214] section 2. **1110-01VV VVVV-VVVV DDDD-DDDD**
ÿ	Channel 2 (12Bit): **0000** (ID 0) **DDDD-DDDD** with **D** = CV data.

The corresponding response datagram (ID 0) does not need to be sent in the same packet frame, but can be sent at a later time. A central unit must therefore ensure that the decoder is addressed again and that no other programming command is sent to the same address beforehand (the same one is permitted).

Once the read operation is complete, the decoder sends the result in response to the corresponding read command. If the decoder does not return the data within 0.5 seconds, the read operation is considered a failure.

5.1.2 Byte Writing

Operation command: POM byte write	
ÿ	Byte writing according to [RCN-214] section 2. **1110-11VV VVVV-VVVV DDDD-DDDD**

ÿ	Channel 2 (12Bit): **0000** (ID 0) **DDDD-DDDD** Here, **D** = CV data returns the value that is present in the CV **after** the POM operation.

When writing, the decoder should respond as follows: With an ACK as long as the new value has not yet been written, with the new value if the new value was successfully written, with an ACK followed by a NACK within a RailCom message if the CV is not supported, or with a different value if the written value cannot be accepted. Instead of an ACK, it can also respond with another non-command-related message.

If the decoder does not return a value within 0.5 seconds, the write operation is considered a failure. For a read-only CV, the decoder returns the current value of the CV.

5.1.3 Bit Writing

Operation command: POM bit write	
ÿ Bit writing according to [RCN-214] Section 2	**1110-10VV VVVV-VVVV 1111-DBBB**
ÿ Channel 2 (12Bit): **0000** (ID 0) **DDDD-DDDD**	Here, **D** = CV data returns the value that is present in the CV **after** the POM operation.

Responses are the same as for "Write Byte." The "Read Bit" command is of no interest to RailCom, as the entire byte is always returned.

5.2 ADR (IDs 1 & 2)

This feedback is used to determine the address of vehicle decoders on the layout. With the help of stationary detectors, it can be used for localization.

Vehicle decoders use channel 1 as a broadcast channel for their own address. They transmit their active address (basic, extended, multiple unit, or possibly additional) in the cutout after each DCC packet addressed to a vehicle decoder (see MOB label in Table 4).
DCC-A address). For this purpose, the following 12-bit datagrams with ID 1 and ID 2 are defined, whereby a DCC-A address is transmitted as the base or extended address:

ADR1 (ID 1)	**ADR2 (ID 2)**	**address**
0 0 0 0 0 0 0 0	**0** A6 A5 A4 A3 A2 A1 A0	Base address (CV1)
0 1 1 0 0 0 0 0	**R** A6 A5 A4 A3 A2 A1 A0	Multiple traction address (CV19)
1 0 A13 A12 A11 A10 A9 A8 A7 A6 A5 A4 A3 A2 A1 A0		Extended address (CV17+CV18)

Table 11: ADR assignment address

Long multiple traction addresses (CVs 19 and 20) are sent like normal long addresses.

A decoder must send the two datagrams ADR1 and ADR2 alternately, depending on its active address. The "active address" is the address at which the decoder receives its driving commands.

Operational Command Response: ADR	
ÿ	Operation command to vehicle decoder according to [RCN-212] Section 2
ÿ Channel	1: **0001** (ID 1) ADR1 or **0010** (ID 2) ADR2

Possible application:

Local detectors on the layout evaluate these datagrams promptly and forward this information (to the control center, computer, etc.). This allows the control center to determine which decoder is located on a specific section of track.
Figure 5 shows this schematically.

This method is particularly suitable for train control.

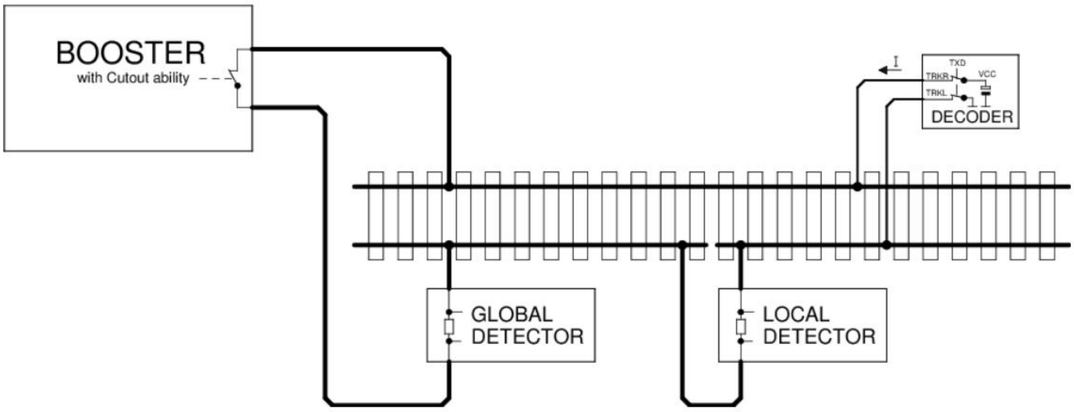

Figure 5: Localization of vehicle decoder

Localizing a decoder according to the above pattern can only work if the decoder is alone on the track section monitored by the local detector.

However, this is problematic in multi-traction operation. For this, it is recommended that only the leading locomotive sends the ADR datagrams on channel 1, while this function is deactivated for the following locomotives via CV28. This can be done when assembling the train via POM.

5.2.1 Dynamic Channel 1 Usage

This automatically disables the transmission of the address on channel 1 to reduce collisions. The decoder transmits on channel 1:

- After a restart
- After a change of address
- If it has not been addressed for more than 5s.

If bit 2 is set in CV28, transmission on channel 1 is automatically disabled after the locomotive's address has been received eight times. This ensures that a new locomotive is recognized and, once addressed by the system, no longer interferes with the detection of other locomotives.

5.2.2 Info1 (ID 3)

To provide additional information to a local detector, the decoder can also cyclically transmit ID 3 on channel 1 in addition to IDs 1 and 2, meaning ID 1, ID 2, ID 3, ID 1, etc. are transmitted in sequence. This must be enabled via CV28 bit 3. Additionally, the conditions for IDs 1 and 2 apply, meaning ID 3 may only be transmitted if IDs 1 and 2 are also enabled on channel 1, and only in the cutout after a DCC packet addressed to a vehicle decoder.

Bit	function
0	Rerailing direction = polarity of the track signal according to [RCN-210] section 2.3 1 = positive, 0 = negative
1	Direction of travel = Polarity of the track signal related to the direction of travel instead of the Decoder connections including CV 29 Bit 1 and if applicable CV 19 Bit 7 (corresponds to bit 1 “OW” in DV 27) 1 = negative, 0 = positive
2	Driving condition 1 = moving, 0 = standing
3	1 = Part of a multiple traction
4	1 = Request for addressing in order to be able to send a message in channel 2
5 – 7	reserved

Table 12 Meaning of ID 3 in channel 1.

5.2.3 Rerailing search (ID 1, 2 and 14)

This is a special application for identifying a vehicle on the layout. To do this, the vehicle is briefly disconnected from the track voltage by tipping it over or by other means. This disconnection must last for at least 1 second. After the decoder receives power again, it responds to the "XF2 off" command to broadcast address 0 with its address on **channel** 2 for a maximum of 30 seconds. During this time, the user must trigger this command via the central unit.

Operational command response: ADR / TIME	
ÿ	Search command: short binary state control command "XF2 off" according to [RCN-212] Section 2.3.5 to broadcast address 0: **1101-1101 0000-0010**
ÿ Channel	2 from the decoder three 12 bit datagrams **0001** (ID 1) **DDDD-DDDD:** adr_high according to Table 11 **0010** (ID 2) **DDDD-DDDD:** adr_low according to Table 11 **1110** (ID 14) **DDDD-DDDD:** Time in seconds since the decoder has voltage again until the first search command is received, regardless of whether he answers it or not.

The decoder should not respond to every "XF2 off" command, but rather statistically (average probability approximately 1:8) to broadcast address 0, so that the rerail search can also detect and list multiple vehicles that are rerailed simultaneously (i.e., one after the other). These may also include false alarms (from vehicles with random, brief contact interruptions), whereby the time information (from the return of voltage to the receipt of the first search command) can help with detection.

The decoder should only respond (statistically) to the "XF2 off" commands as long as the sequence of "XF2 off" commands is not interrupted for more than 1 second, i.e. the time difference between two received "XF2 off" commands is not greater than 1 second.

It is recommended to send the "XF2 off" command about 8 times per second.

5.2.4 Decoder registration via programming address 0000

This is a very simple method for detecting (new) decoders on the layout. It can be used with a global or, preferably, a local RailCom detector. Only one decoder can be detected at a time.

The central unit sends a special registration command every 2 to 3 seconds. This command consists of the 14-bit vehicle address "0" with a POM read command on CV29. Only decoders with the registration bit "4" set in CV28 are allowed to respond to this command.

If the decoder doesn't receive a registration command within 5 seconds despite bit 4 in CV 28 being active, it returns to normal operating mode. Until then, it ignores its address.

The central unit evaluates the received contents of CV29. Depending on the result, it then queries the 7-bit or 14-bit vehicle address via POM. If bit 7 in CV29 is set, it can also query the 11-bit accessory address.

In a dialog with the user, the new decoder is permanently or temporarily added to the internal database. If the short vehicle address 3 or the accessory address 1 has been read, a suggestion for the new address assignment can be made. The same applies if the read address is stored in the database for another vehicle.

After registration is complete, bit 4 in CV29 should be automatically deleted by the control unit.

If this registration procedure is supported, bit 4 in CV 28 should be set at the factory and should also be set when the decoder is reset by programming CV 8 to 8. In addition to the normal programming procedures, a special value written to CV 8 can also be used to set bit 4 in CV 28.

5.3 EXT (ID 3)

This feedback is used to transmit location information. This allows the location of the vehicle decoder at a given address to be determined and, if necessary, to trigger a refill of supplies.

5.3.1 Sending location information

The location information can be sent by the decoder or the detector, depending on where the information is located.

Case 1: Location information is available in the decoder (e.g. through infrared transmission).

Operation command response: EXT	
ÿ short binary state control command "XF1 off" according to [RCN-212] Section 2.3.5: **1101-1101 0000-0001**	
ÿ Channel 2 from decoder: **0011** (ID 3) **00 TTTT-PPPP-PPPP** with: **TTTT** = **0000** – **0111:** Location information (position): **0PPP** **TTTT** = **1000** – **1111:** reserved **0PPP-PPPP-PPPP:** 11 bit location address (position)	

If the location information is present in the decoder, it can also be transmitted spontaneously on channel 2 with the ID DYN. See section 5.4.

Case 2: Location information is available in the Detector.

Operation command response: EXT	
ÿ short binary state control command "XF1 off" according to [RCN-212] Section 2.3.5: **1101-1101 0000-0001**	
ÿ Channel 2 from the decoder: **0011** (ID 3) **01**	Channel 2 of Detector: **TTTT-PPPP-PPPP** **TTTT** = **0000** – **0111:** location information only **TTTT** = **1000:** reserved **TTTT** = **1001:** reserved **TTTT** = **1010:** diesel filling station **TTTT** = **1011:** Coal bunkers **TTTT** = **1100:** Water tap **TTTT** = **1101:** Sanding plant **TTTT** = **1110:** charging station (battery) **TTTT** = **1111:** General filling station **PPPP-PPPP:** 8-bit location address (position)

The detector works as shown in Figure 5, but is supplemented by a RailCom transmitter.
Since the location information is sent back via the track, no further connection to a bus system, for example, is necessary.

5.3.2 Filling

Filling a container or all containers is done with the "Write Byte" command from Section 5.1.2 on the corresponding CVs in the RailCom block (CV31=0 & CV32=255).

5.4 Current travel information (ID 4)

This message is intended to transmit current information about the running status initiated by the decoder to the central unit. Unlike DYN (ID 7), 32 bits instead of 8 can be transmitted in a datagram. Since there is no precise specification yet, ID 4 is currently only reserved.

5.5 DYN (ID 7)

This feedback is used to transmit dynamic information from vehicle decoders. Dynamic Information refers to Dynamic Variables (DVs).
which change during operation (e.g. speed, tank content, etc.).
The RailCom CVs 64-127 (see section 4.2.4, Table 9) correspond to DVs that can be changed by programming.

Operation command response: DYN	
ÿ	Operation command to decoder address according to [RCN-212] Section 2
ÿ	Channel 2 18Bit [+ 18Bit]: **0111** (ID 7) **DDDD-DDDD-XXXX-XX** **[0111** (ID 7) **DDDD-DDDD-XXXX-XX]** with **D** = DV value and **X** = subindex to identify the DV

Dynamic variables (DV) (e.g., speed, container, etc.) are transmitted in an 18-bit datagram (ID 7), which contains the 8-bit DV value **(D)** and a 6-bit subindex **(X)** that selects one of 64 possible DVs. The meaning of the DV is determined by the subindex.

Any two DVs can be transmitted in a response frame. A decoder determines which DVs to send and when.

X	**Meaning**
0	Real Speed Part 1 [1])
1	Real Speed, Part 2 [1])
2	**0LLL LLLL** = Load according to Susi specification **1GGG GGGG** = speed, standardized to 128 speed steps
3	RailCom version as 2x 4 bit "main version minor version", 0x15 = version 1.5
4	Change flags (change flags from RCN-218)
5	Flag Register, content to be determined
6	Input Register, assignment to be determined
7	Reception statistics: The vehicle decoder keeps statistics on all received DCC packets and transmits the number of faulty packets / total number in %. (Value range 0-100).
8	Contents of container 1 in % (value range 0-100)
9	Contents of container 2 in % (value range 0-100)
10	Contents of container 3 in % (value range 0-100)

11	Contents of container 4 in % (value range 0-100)
12	Contents of container 5 in % (value range 0-100)
13	Contents of container 6 in % (value range 0-100)
14	Contents of container 7 in % (value range 0-100)
15	Contents of container 8 in % (value range 0-100)
16	Contents of container 9 in % (value range 0-100)
17	Contents of container 10 in % (value range 0-100)
18	Contents of container 11 in % (value range 0-100)
19	Contents of container 12 in % (value range 0-100)
20	Datagram 1: Location address least significant 8 bits Datagram 2: Location address most significant 3 bits in bits 0 to 2, Bits 3 to 7 are reserved to be set to 0. [2])
21	warning and alarm messages [3])
22	trip odometers, exact definition to be determined
23	Maintenance interval [4])
24-25	reserved
26	Temperature: Value range from 0 = -50°C to 255 = +205°C
27	direction state bytes for east-west control. [5])
28-45	Reserved
46	Track voltage measured by the decoder = 5V + value * 100 mV
47	Stopping distance calculated by the decoder in m to standstill, unit 4 m (Maximum value 1 km for the prototype)
48-63	Reserved

Table 13: Dynamic information vehicle decoder

[1]) Note on transmitting the actual speed: The decoder calculates the actual speed traveled on the layout. This calculation is manufacturer-dependent due to the dependence on the decoder's internal software structure. The values are in km/h. Any necessary conversion to mph is carried out in the display unit. Up to a value of 255, the transmission takes place exclusively in ID 7 DYN 0. If the speed is higher, only(!) the difference (i.e., the calculated speed in km/h minus 256) is transmitted in ID 7 DYN 1. This means that the most significant bit of the speed is the least significant bit in the subindex for identifying the DV:

RailCom message: **0 1 1 1 | DDDD - DDDD | 0 0 0 0 - 0 D**

Speed: ID7 G7 G6 G5 G4 - G3 G2 G1 G0 Subindex G8

For the scaling of the speedometer on the display device, reference is made to byte 145 (= CV 402) in the RailCom block addressed via CV31 = 0 and CV32 = 255 (section 4.2.4).

[2]) For the location address DV 20, both address parts are in one 18-bit datagram each within a channel, with the least significant 8 bits being transmitted first. For addresses < 256, a single datagram is sufficient.

[3]) The status and alarm messages in DV 21 are defined as follows:

Bit 7 = 0: warning, Bit 7 = 1 alarm.

Bit 6 = 0 Warnings or alarms independent of other DVs according to Table 14.
All values not listed there are reserved.
Bit 6 = 1 Warnings or alarms related to DVs 0 to 63. The DV number is in bits 0 to 5.

Value	Meaning
128 = **1000 0000** Alarm	short circuit motor output
129 = **1000 0001** Alarm	short circuit function output
130 = **1000 0010** Overtemperature alarm	

Table 14: Warnings and alarms independent of DVs

[4]) Writing 255 to the DV via RailCom CV 87 resets the maintenance interval counter. The decoder decrements the counter (configurable if required) depending on the operating status. When a threshold value is exceeded or 0 is reached, a warning or alarm is sent via DV21.

[5]) Feedback to the special mode command defined in [RCN-212] section 2.2.3.

• Bit 0: "VR" • Bit 1: "OW" • Bit 2: Direction control Vehicle-related direction in which to drive. System-related direction of travel: 0 = West, 1 = East
0 = direction according to drive command,
1 = Direction according to the east-west control
• Bit 3: Change of direction
0 = normal, 1 = locomotive in braking phase within a direction change
• Bit 4: OW hide
0 = normal, 1 = EW direction arrows should **not** be displayed.
• Bit 5: OW-Inverse
0 = normal, 1 = display of the other direction arrow.
• Bits 6 & 7: Reserved

"West" is defined as forward with positive track signal polarity according to [RCN-210] Section 2.3, and reverse with negative polarity. "East" is defined in the reverse direction.

5.6 XPOM (ID 8 to ID 11)

POM stands for "Programming On the Main," meaning programming on the track for operation. XPOM is an extended format compared to POM defined in section 5.1 for writing and reading up to four CVs in operating mode according to [RCN-214]
Section 4. These commands are responded to in channel 2 with a 36-bit datagram with ID 8 =

1000 to ID 11 = **1011** and 32 data bits. The data bits contain the value of four consecutive CVs.

Operating command: XPOM	
ÿ Access to bytes or bits according to [RCN-214] Section 4	**1110-KKSS VVVV-VVVV VVVV-VVVV VVVV-VVVV {DDDD-DDDD {DDDD-DDDD {DDDD-DDDD {DDDD-DDDD}}}}**
ÿ Channel 2 (36 bit): **10SS** (ID 8 - 11) **DDDD-DDDD DDDD-DDDD DDDD-DDDD DDDD-DDDD**	with **D** = CV data

Regardless of the number of bytes written and even when only one bit is written, the values of four CVs are always returned.

The assignment between command and response is done by sequence number SS and Datagram ID as follows:

SS = **00** – ID 8 **1000**
SS = **01** – ID 9 **1001**
SS = **10** – ID 10 **1010**
SS = **11** – ID 11 **1011**

The response datagram associated with the XPOM command (ID 8 ID 11) does not have to be sent in the same packet frame, but can be sent at a later time.

The decoder must implement a queue for four XPOM commands and process them sequentially. Repeatedly sent XPOM commands with the same sequence number are only added to the queue once. The associated response datagram completes the operation and releases the corresponding entry in the queue. When writing via XPOM, the response is only sent after the actual write operation. This allows the command station to synchronize to the decoder's write speed. If no response datagram is received, the last command with the same sequence number must be sent again. When writing read-only CVs, the decoder returns the current value of the CVs. The command station must determine whether a write access has been accepted by comparing the command and response.

In particular, the decoder must support fast, block-wise reading, ie for consecutive XPOM read commands,

the response of the 1st XPOM read command must be sent at the latest
in the cutout of the 3rd XPOM read command,
the response of the 2nd XPOM read command at the latest in the cutout of the
4. XPOM read command is sent,
the response of the 3rd XPOM read command must be sent at the latest
in the cutout of the 5th XPOM read command,
...

This makes very fast reading possible.

5.6.1 XPOM Byte Read

Operation command: XPOM Byte Read	
ÿ	Read bytes according to [RCN-214] section 4. **1110-01SS VVVV-VVVV VVVV-VVVV VVVV-VVVV**
ÿ Channel	2 (36 Bit): **10SS** (ID 8-11) CV[V+0] CV[V+1] CV[V+2] CV[V+3]

At the time of feedback, the preceding text must be observed.

5.6.2 Byte Writing

Operation command: POM byte write	
ÿ	Byte writing according to [RCN-214] section 4. **1110-11SS VVVV-VVVV VVVV-VVVV VVVV-VVVV {DDDD-DDDD {DDDD-DDDD {DDDD-DDDD {DDDD-DDDD}}}}**
ÿ Channel	2 (36 Bit): **10SS** (ID 8-11) CV[V+0] CV[V+1] CV[V+2] CV[V+3]

When returning the CV, please note the preceding text. The CV values are always returned as they were after the write operation, even if the write operation could not be executed or could only be partially executed due to a limited value range.

5.6.3 Bit Writing

Operation command: XPOM bit write	
ÿ	Bit writing according to [RCN-214] Section 4 **1110-10SS VVVV-VVVV VVVV-VVVV VVVV-VVVV 1111-DBBB**
ÿ Channel	2 (36 Bit): **10SS** (ID 8-11) CV[V+0] CV[V+1] CV[V+2] CV[V+3]

Responses are the same as for "Write Byte." The "Read Bit" command is of no interest to RailCom, as the entire byte is always returned.

5.7 CV-Car (ID 12)

This feedback is used to transmit CVs from vehicle decoders in the background.
The decoder can send CVs at any time. Command X3 can initiate the transmission of all CVs:

Operating command response: CV-Auto	
ÿ	short binary state control command "XF3 on" according to [RCN-212] Section 2.3.5: **1101-1101 0000-0011**
ÿ Channel	2 from the decoder: ACK or any response that may be sent spontaneously – also but not necessarily CV-Auto

The decoder then sends all its CVs when it is addressed and channel 2 is available. However, for transmission security, this is not done in blocks; instead, each response contains all the necessary information to evaluate the message.

Operation command response: Cancel CV-Auto	
ÿ short binary state control command "XF3 off" according to [RCN-212] Section 2.3.5: **1101-1101 0000-0011**	
ÿ Channel 2 from the decoder: ACK or any response sent spontaneously may be – but no longer CV-car	

The decoder has to stop sending its CVs.

Operating command response: CV-Auto	
ÿ	Operation command to decoder address according to [RCN-212] Section 2
ÿ	Channel 2 36 bits: **0100** (ID 4) VVVV-VVVV VVVV-VVVV VVVV-VVVV **DDDD-DDDD**

VVVV-VVVV VVVV-VVVV VVVV-VVVV is the 24-bit address of the transferred CV. The higher-order address bits are transferred in the first byte. Compared to access via CVs 31 and 32, this means that the first **VVVV-VVVV** byte corresponds to the contents of CV 31, the second **VVVV-VVVV** byte corresponds to the contents of CV 32, and the third **VVVV-VVV** byte corresponds to the second byte of the "Access Command - Long Form" according to [RCN-214] . This allows all CVs of a decoder to be addressed. The eight bits **DDDD-DDDD** contain the value stored in the CV.

6 Application for accessory decoders (switches etc.)

6.1 SRQ - Service Request for Accessory Decoders

Channel 1 of the cutout is used by accessory decoders to request communication from the central unit. This request is referred to below as an SRQ (Service Request).

The SRQ can be sent either after any accessory decoder packet (regardless of the address it addresses and whether it is a Simple or Extended Accessory Control packet) or after a NOP if the own address is less than or equal to the address contained in the NOP. (See Chapter 4.3.4)

If an SRQ follows a NOP, the corresponding message must be sent on channel 2 to save some time. However, if the SRQ follows a regular accessory decoder command, the message must not be sent to avoid obscuring the messages of the addressed decoder.

The SRQ is a 12-bit datagram. Unlike all other datagrams, the SRQ does not contain an identifier; instead, the 12 useful bits are used to transmit the complete accessory address.

In the operating instructions for accessory decoders, the address and data are combined in such a way that the address is part of the specified instruction. Therefore, the entire instruction packet (but without the sync bits and check byte) is shown here.

Accessory control operating commands:	
ÿ	Simple accessory control according to [RCN-213] section 2.1 **10AA-AAAA 1AAA-DAAR**
ÿ	Advanced accessory control according to [RCN-213] section 2.3 **10AA-AAAA 0AAA-0AA1 DDDD-DDDD**
ÿ	NOP command for simple and advanced accessory decoders according to [RCN-213] Section 2.5 **10AA-AAAA 0AAA-1AAT**
ÿ ÿ	Channel 1: **0** A10 A9 A8 A7 A6 A5 A4 A3 A2 A1 A0 (Simple accessory decoder) Channel 1: **1** A10 A9 A8 A7 A6 A5 A4 A3 A2 A1 A0 (Extended Accessory Decoders)
ÿ	Channel 2 only when responding to NOP: message concerning the SRQ, e.g. error

By limiting the address resolution of simple accessory decoders to output pairs, an 11-bit address is obtained, just like with extended accessory decoders, and the 12th bit of the SRQ datagram can therefore be used to distinguish between these two categories.

Once a decoder has sent an SRQ, it must repeat it until it has been handled.
During this time, the decoder must not respond to any control commands directed at it.

An SRQ is considered processed when the decoder has received a clear command at its own address. The "Coil Off" command or the "Absolute Stop" command serves as a clear command. In this state, the aforementioned commands are not executed as such, but merely cause the SRQ to no longer be sent.

Delete command for simple accessory decoders: Coil off

Format: **10AA-AAAA 1AAA-0AA0**

Delete command for extended accessory decoders: Absolute stop (=Aspect 0)

Format: **10AA-AAAA 0AAA-0AA1 0000-000**

Note: A RailCom-capable command station regularly sends a NOP to enable SRQs. If an accessory decoder does not receive any NOPs within the first five seconds after first receiving the DCC format, it can assume that the command station is not RailCom-capable, thus no SRQs can be processed, and no need to send any. In this case, the decoder's function is not blocked.

6.2 POM (ID 0)

POM stands for "Programming On the Main," meaning programming on the track for operation. Since accessory decoders are usually permanently connected to the digital signal for operation, these commands allow reading and writing configuration variables in operating mode according to [RCN-214] Section 2. These commands are responded to on channel 2 with a 12-bit datagram with ID 0 = **0000** and 8 data bits. The data bits contain the value of the CV.

The POM commands from the command station to the decoder (ÿ) are written without the addressing data. Addressing is performed according to [RCN-214] Section 2.1.

Operating commands: POM	
ÿ Access	to bytes or bits according to [RCN-214] Section 2 **1110-KKVV VVVV-VVVV DDDD-DDDD** **1110-10VV VVVV-VVVV 111K-DBBB**
ÿ Channel	2: **0000** (ID 0) **DDDD-DDDD** with **D** = CV data

6.2.1 Byte Reading

Operation command: POM byte read	
ÿ Read B	yte Command according to [RCN-214] Section 2 **1110-01xx**
ÿ Channel	2 (12Bit): **0000** (ID 0) **DDDD-DDDD** with **D** = CV data.

The corresponding response datagram (ID 0) does not need to be sent in the same packet frame, but can be sent at a later time. A central unit must therefore ensure that the decoder is addressed again and no other command is sent to this decoder (the same command is permitted).

Once the read operation is complete, the decoder sends the result in response to the corresponding read command. If the decoder does not return the data within 0.5 seconds, the read operation is considered a failure.

6.2.2 Byte Writing

Operation command: POM byte write	
ÿ Comma	nd Byte Write according to [RCN-214] Section 2 **1110-11xx**
ÿ Channel	2 (12Bit): **0000** (ID 0) **DDDD-DDDD** Here, **D** = CV data returns the value that is present in the CV **after** the POM operation.

If the decoder does not provide the data within 0.5s, the write operation is considered to have failed.

For a CV that can only be read, the decoder returns the current value of the CV.

6.2.3 Bit Writing

Operation command: POM bit write	
ÿ Comma	nd Bit Write according to [RCN-214] Section 2 **1110-10xx**

ÿ Channel 2 (12Bit):	**0000** (ID 0) **DDDD-DDDD** Here, **D** = CV data returns the value that is present in the CV **after** the POM operation.

Answers as in "Write Byte".

6.3 STAT1 (ID 4)

This feedback is used to transmit status messages from accessory decoders, Part 1

Operation command response: STAT1	
ÿ Operation command to decoder address according to [RCN-213] section 2.1 or 2.3	**10AA-AAAA 1AAA-DAAR** or **10AA-AAAA 0AAA-0AA1**
ÿ Channel 2 12Bit:	**0100** (ID 4) **DDDD-DDDD**

The status code can be returned as an acknowledgment after accessory decoder commands. An "ACK" is then omitted.

1. Datagram for simple accessory decoders:

bit	**Meaning**
11 ... 8	Identifier 0x4
7	reserved
6	0: Output state does not match the last received command. 1: Output state matches the last received command.
5	0: the reported state is the setpoint 1: the reported state is the actual value based on real feedback
4 ... 0	Current state. E.g., switch decoders have 2 output states

Table 15: Status messages for simple accessory decoders.

Since only five bits are available for the current state, extended accessory decoders transmit the status in two datagrams. The two datagrams should be transmitted together in the channel. If only the datagram for bits 4 to 0 of the current state is transmitted, bits 7 to 5 are assumed to be 0.

Datagrams for extended accessory decoders:

bit	**Meaning**
11 ... 8	Identifier 0x4
7 = 0:	
6	0: Output state does not match the last received command. 1: Output state matches the last received command.
5	0: the reported state is the setpoint

	1: the reported state is the actual value based on real feedback
4 ... 0 Bit	4 … 0 of the current state
7 = 1:	
6 … 3 reserved	
2 … 1 Bit	7 … 5 of the current state

Table 16: Status messages for extended accessory decoders.

6.4 STAT4 (ID 3)

This feedback is used to transmit the status of all four output pairs of simple Accessory decoders.

Operation command response: STAT4	
ÿ Operation	command to decoder address according to [RCN-213] section 2.1 **10AA-AAAA 1AAA-DAAR** or **10AA-AAAA 0AAA-0AA1**
ÿ Channel	2 12 bit: **0100** (ID 3) **DDDD-DDDD**

The status can be returned as an acknowledgment after accessory decoder commands. An "ACK" is then omitted. The response contains the feedback for each of the 8 outputs, where a 1 means that the feedback contact is closed or the end position has been reached. The assignment of the outputs to the bits in the transmitted byte is as follows.

Output pair	4		3		2		1	
R-bit in the command to select this output (key color)	0 (R)	1 (G)	0 (R)	1 (G)	0 (R)	1 (G)	0 (R)	1 (G)
Bit in the byte transmitted via RailCom	7	6	5	4	3	2	1	0

Table 17: Accessory decoder status byte

According to [RCN-213], in the command for simple accessory decoders, R = 0 means switch on branch or direction of travel left or signal on stop (classic red button) and R = 1 means switch straight or direction of travel right or signal on go (classic green button).

The structure of this byte corresponds to the content of CV 33 in accessory decoders. This CV can be read by central units via POM (section 6.2.1) to determine the status of the outputs. of the decoder.

6.5 TIME (ID 5)

This feedback is used to transmit the forecasted orbital time

Operational command response: TIME	
ÿ Operation	command to decoder address according to [RCN-213] section 2.1 or 2.3

	10AA-AAAA 1AAA-DAAR or **10AA-AAAA 0AAA-0AA1**
ÿ Channel 2 12Bit: **0101** (ID 5) **DDDD-DDDD**	

This command confirmation can be returned as an acknowledgment after accessory decoder commands. An "ACK" can then be omitted.

The 7 lowest-order bits of the remaining runtime indicate the runtime until the end state of this term is reached (predicted round trip time). Depending on the MSB, the time is specified in 1/10 of a second (MSB = 0) or 1 second (MSB = 1). A time of 0 means no switching time—e.g., for signal decoders without incandescent lamp simulation. This results in a value range of 0 to 12.7 seconds or 0 to 127 seconds.

1. Datagram

bit	Meaning
11 ... 8	Identifier 0x5
7	0: Resolution 1/10 second 1: Resolution 1 second
6 ... 0	Predicted orbital time

Table 18: predicted turnaround time

6.6 ERROR (ID 6)

This feedback is used to transmit error information

Operation command response: ERROR	
ÿ Operation command to decoder address according to [RCN-213] Section 2 (including NOP)	
ÿ Channel 2 12Bit: **0110** (ID 6) **DDDD-DDDD**	

The error code can be returned after any instruction that addresses the decoder, including NOP. An "ACK" is then omitted.

The error message transmission is cleared by a new switching command. If a permanent error exists, the decoder may not trigger a new SRQ as long as the same error is present. Therefore, after clearing the error, the central unit must contact the decoder again to determine whether the error is permanent.

bit	Meaning
11 ... 8	Identifier 0x6
7	reserved
6	0: Only the error specified in the following 6 bits is present. 1: There are other errors besides the one indicated.

5 ... 0	Error code meaning	
	0x00	No error (anymore)
	0x01	Command could not be executed, unknown command / invalid aspect.
	0x02	Drive current consumption too high.
	0x03	Supply voltage too low, function is not guaranteed.
	0x04	Fuse defective.
	0x05	Temperature too high.
	0x06	Feedback error (unintentional adjustment detected)
	0x07	Manual adjustment (e.g. via button on the decoder)
	0x10	Switch lamp or signal lamp defective
	0x20	Servo defective.
	0x3F	Internal decoder error, e.g. self-test processor checksum faulty.

Table 19: Error messages

6.7 DYN (ID 7)

This feedback is used to transmit dynamic information from accessory decoders. "Dynamic information" refers to CV contents (RailCom CVs) that change during operation.

Operation command response: DYN	
ÿ	Operation command to decoder address according to [RCN-213] section 2.1 or 2.3 **10AA-AAAA 1AAA-DAAR** or **10AA-AAAA 0AAA-0AA1**
ÿ	Channel 2 18Bit+[18Bit]: **0111** (ID 7) **DDDD-DDDD-XXXX-XX** **[0111** (ID 7) **DDDD-DDDD-XXXX-XX]**

The transmission of dynamic variables (DV) takes place in an 18-bit datagram (ID 7), which contains the 8-bit value of the DV (D) and a 6-bit subindex (X) that selects one of 64 possible DVs. The meaning of the DV is determined by the subindex.
Any two DVs can be transmitted in a response frame. A decoder determines which DVs to send and when.

X	Meaning
0	Flag Register, content to be determined
1-2	Reserved
3	RailCom version as 2x 4 bit "main version minor version", 0x15 = version 1.5 change flags
4	(change flags from RCN-218)

5	Flag Register, content to be determined
6	Input Register, assignment to be determined
7	Reception statistics: The accessory decoder keeps statistics on all received DCC packets and transmits the number of faulty packets / total number in %. (Value range 0-100).
8	Contents of container 1 in % (value range 0-100)
9	Contents of container 2 in % (value range 0-100)
10	Contents of container 3 in % (value range 0-100)
11	Contents of container 4 in % (value range 0-100)
12	Contents of container 5 in % (value range 0-100)
13	Contents of container 6 in % (value range 0-100)
14	Contents of container 7 in % (value range 0-100)
15	Contents of container 8 in % (value range 0-100)
16	Contents of container 9 in % (value range 0-100)
17	Contents of container 10 in % (value range 0-100)
18	Contents of container 11 in % (value range 0-100)
19	Contents of container 12 in % (value range 0-100)
20	reserved
21	warning and alarm messages [6])
22-63	reserved

Table 20: Dynamic information

[6]) The status and alarm messages in DV 21 are defined as follows:

Bit 7 = 0: warning, Bit 7 = 1 alarm.

Bit 6 = 0 Warnings or alarms independent of other DVs according to Table 21.
All values not listed there are reserved.
Bit 6 = 1 Warnings or alarms related to DVs 0 to 63. The DV number is in bits 0 to 5.

Value	**Meaning**
128 = **1000 0000**	Alarm short circuit switching output 1
129 = **1000 0001**	Alarm short circuit switching output 2
130 = **1000 0010**	Alarm short circuit switching output 3
131 = **1000 0011**	Alarm short circuit switching output 4
132 = **1000 0100**	Alarm short circuit switching output 5
133 = **1000 0101**	Alarm short circuit switching output 6

134 = **1000 0110** Alarm short circuit switching output 7	
135 = **1000 0111** Alarm short circuit switching output 8	
136 = **1000 1000** Overtemperature alarm	

Table 21: Warnings and alarms independent of DVs

6.8 XPOM (ID 8 to ID 11)

POM stands for "Programming On the Main," meaning programming on the track for operation. XPOM is an extended format compared to POM defined in section 6.2 for writing and reading up to four CVs in operating mode according to [RCN-214] Section 4. These commands are responded to on channel 2 with a 36-bit datagram with ID 8 = **1000** to ID 11 = **1011** and 32 data bits. The data bits contain the value of four consecutive CVs.

Operating command: XPOM	
ÿ Access to bytes or bits according to [RCN-214] Section 4	**1110-KKSS VVVV-VVVV VVVV-VVVV VVVV-VVVV {DDDD-DDDD {DDDD-DDDD {DDDD-DDDD {DDDD-DDDD}}}}**
ÿ Channel 2 (36 bit): **10SS** (ID 8 - 11) **DDDD-DDDD DDDD-DDDD DDDD-**	**DDDD DDDD-DDDD** with **D** = CV data

Regardless of the number of bytes written and even when only one bit is written, the values of four CVs are always returned.

The assignment between command and response is done by sequence number SS and Datagram ID as follows:

SS = **00** – ID 8 **1000**

SS = **01** – ID 9 **1001**

SS = **10** – ID 10 **1010**

SS = **11** – ID 11 **1011**

The response datagram associated with the XPOM command (ID 8 ID 11) does not have to be sent in the same packet frame, but can be sent at a later time.

The decoder must implement a queue for four XPOM commands and process them sequentially. Repeatedly sent XPOM commands with the same sequence number are only added to the queue once. The associated response datagram completes the operation and releases the corresponding entry in the queue. When writing via XPOM, the response is only sent after the actual write operation. This allows the command station to synchronize to the decoder's write speed. If no response datagram is received, the last command with the same sequence number must be sent again. When writing read-only CVs, the decoder returns the current value of the CVs. Whether a write access was accepted must be determined by the control center by comparing the command and the response.

In particular, the decoder must support fast, block-wise reading, ie for consecutive XPOM read commands,

the response of the 1st XPOM read command must be sent at the latest in the cutout of the 3rd XPOM read command,

the response of the 2nd XPOM read command at the latest in the cutout of the 4. XPOM read command is sent,

the response of the 3rd XPOM read command must be sent at the latest in the cutout of the 5th XPOM read command,

...

This makes very fast reading possible.

6.8.1 XPOM Byte Read

Operation command: XPOM Byte Read	
ÿ	Read bytes according to [RCN-214] section 4. **1110-01SS VVVV-VVVV VVVV-VVVV VVVV-VVVV**
ÿ	Channel 2 (36 Bit): **10SS** (ID 8-11) CV[V+0] CV[V+1] CV[V+2] CV[V+3]

At the time of feedback, the preceding text must be observed.

6.8.2 Byte Writing

Operation command: POM byte write	
ÿ	Byte writing according to [RCN-214] section 4. **1110-11SS VVVV-VVVV VVVV-VVVV VVVV-VVVV {DDDD-DDDD {DDDD-DDDD {DDDD-DDDD {DDDD-DDDD}}}}**
ÿ	Channel 2 (36 Bit): **10SS** (ID 8-11) CV[V+0] CV[V+1] CV[V+2] CV[V+3]

When returning the CV, please note the preceding text. The CV values are always returned as they were after the write operation, even if the write operation could not be executed or could only be partially executed due to a limited value range.

6.8.3 Bit Writing

Operation command: XPOM bit write	
ÿ	Bit writing according to [RCN-214] Section 4 **1110-10SS VVVV-VVVV VVVV-VVVV VVVV-VVVV 1111-DBBB**
ÿ	Channel 2 (36 Bit): **10SS** (ID 8-11) CV[V+0] CV[V+1] CV[V+2] CV[V+3]

Responses are the same as for "Write Byte." The "Read Bit" command is of no interest to RailCom, as the entire byte is always returned.

6.9 STAT2 (ID 8)

Not intended for new designs, but already used by components on the market. For other uses of ID 8, the length of the datagram is
used as a distinguishing feature.

This feedback is used to transmit status messages from accessory decoders Part 2 Specially tailored for mechanical control operations.

Operation command response: STAT2	
ÿ Operation	command to decoder address according to [RCN-213] section 2.1 or 2.3 **10AA-AAAA 1AAA-DAAR** or **10AA-AAAA 0AAA-0AA1**
ÿ Channel 2 12Bit:	**1000** (ID 8) **DDDD-DDDD** with **D** = data according to Table 22, bits 7 … 0

1. Datagram

bit	Meaning
11 ... 8	Identifier 0x8
7 ... 4	Configuration, previously defined: 0000 — Uncoupler 0001 — Switch 0010 — Three-way switch 0011 — Double crossing switch 1000 — Track blocking signal 1001 — Form signal Hp0/Hp1 1010 — shape signal Hp0/Hp1/Hp2 1011 — Distant signal Vr0/Vr1 1100 — distant signal Vr0/Vr1/Vr2 1101 — Railway barrier
3	0: The setting process … 0 reported state corresponds to the setpoint, or in bits 2 is still ongoing. 1: The reported state corresponds to the actual value based on real feedback.
2 ... 0	Current status

Table 22: Status messages, part 2

Annex A: References to other standards

A.1 Normative references

[RCN-210] RCN-210 DCC packet structure

[RCN-211] RCN-211 DCC packet structure, address ranges and global commands

[RCN-212] RCN-212 DCC operating commands for vehicle decoders

[RCN-213] RCN-213 DCC operating commands for accessory decoders

[RCN-214] RCN-214 DCC configuration commands

A.2 Informative references

The standards and documents listed here are for information purposes only and are not part of this standard.

[RCN-225] RCN-225 DCC configuration variables
[RCN-218] RCN-218 DCC Automatic Login
[TN-217] TN-217 File transfer via RailCom3
[S-9.2.1.1] NMRA: S-9.2.1.1 Advanced Extended Packet Formats
[S-9.2.2 Appendix A] NMRA: S-9.2.2 Appendix A DCC Manufacturer ID codes

Appendix B: History

Date	Chapter	Changes from the previous version	version
July 27, 2025	5.2 5.2.3 5.2.4 5.5	Note for long multiple traction addresses added Specifications and specifications for the rerailing search Decoder registration via programming address 0000 (instead of 0003) added Load and speed added to ID 7 DYN.	1.5
July 21, 2024	2.2 3.1 4.2.1 5.2.2 5.5 6.4	Determination of the polarity of the feed as a recommendation Note for sending in channel 1 after each packet Addition of ID 3 Info1 in channel 1 IDs 15 & 15 used by RailComPlus Bit added to enable ID 3 in channel 1. New section: Definition of ID 3 Info1 in channel 1 Footnote to speed report revised with Reference to byte 145 in the RailCom block Definition of West and East added CV 33 for the status of the outputs now standardized	1.5
November 26, 2023	3.1 / 5.7 3.2 / 6.4 4.3.1 5.4 6.7	MOB ID 12 now CV-Auto instead of former Test Feature ID app:Stat4 (STAT ID 3) for transmitting the status of four output pairs of a simple accessory decoder only one byte long XF 3 to start CV transmission with CV-Auto First draft for the current driving information (ID 4) DVs 3 to 19 and 21 were taken from the vehicle decoders for the accessory decoders.	1.5
July 23, 2023	3.1 3.2	MOB ID 4 now Current driving information with 36 bit Reference at ID 13 to TN-217 to be created STAT ID 3 now Stat4 to transfer the status of four Output pairs of a simple accessory decoder	1.5

[3] The TN-217 has yet to be created

	5.4 6.4	New: ID 7 DYN Subindex 3 and 4 for RailCom version and change flags New: Sending the status of four output pairs	
December 12, 2021	2.4 3 3.1 4.2.4 5.4 6.3	Addition Ready to receive after 75 µs if possible. Responses in channel 1 in Table 4 and in the text Channel bundling for automatic registration [RCN-218] Separate tables for the identifiers for the two channels Determining the order of datagrams. Value range byte 144 0..100 instead of 0..255 Request for address assignment via [RCN-218] Addition of alarm overtemperature – Subindex 21 Explanation of direction status byte – Subindex 27 Addition of measured track voltage – Subindex 46 Addition of calculated stopping distance – Subindex 47 Extension of STAT1 for extended accessory decoders	1.4
December 1, 2019	3.1 / 3.2 5.2.2 5.4	Command reference in Tables 6 and 7 Duration of the interruption determined DV 27 defined as direction state byte	1.3
11.08.2019	5.2.2 5.4 6.7	Rerail search time uses ID 14 instead of ID 0. DVs 21, 23 and 26 are further specified. XPOM is also fully explained in this chapter.	1.2
December 2, 2018	4.3 until 6.8 1.1 & 1.2 2.2 2.5 3 3 & 4.2.1 3.1 & 3.2 4.2.1 5.1.2 5.2.1 5.2.2 5.3.1 5.4 5.5 & 6.7	Fundamental revision with DCC package definitions only informative and references to the corresponding RCN Sections 1.1 and 1.2 adjusted accordingly New: High- current RailCom Response NACK All possible datagram combinations permitted Long address 3 instead of 253 as programming address Sections 3.1 and 3.2 List of IDs revised. CV 28 adapted according to other changes Response when writing bytes further specified New: Dynamic channel 1 usage New: Re-rail search Sending of location information: Letter P instead of O Further DV defined New: XPOM	1.1
December 18, 2016	All	First version based on specification RailCom V 1.4 from April 2015 by Lenz	1.0