1 General

1.1 Introduction and Intended Use (Informative)

This standard describes an extended protocol for bidirectional communication between a SUSI Host and SUSI Modules. This standard is based on the SUSI standard communication and is compatible with it. Mixed operation of BiDi and standard modules is possible as long as they respect the [S-9.4.1 / RCN-600]. Modules according to the old Dietz or NMRA standard may show deviations (see [S-9.4.1] Appendix B: Identified problems with incompatibility to the standard).

1.2 References

This standard should be interpreted in the context of the following NMRA Standards, Technical Notes, and Technical Information.

1.2.1 Normative

When using the corresponding interface, the following standards must be complied:

- [S-9.4.1] SUSI bus communication interface
- [RCN-600] SUSI bus module expansion interface.
- [S-9.4.2] SUSI bus configuration variables
- [RCN-602] Configuration variables for SUSI.
- [NEM 672] Signal Control – Advanced Accessory Decoder Control (DCC)

1.2.2 Informative

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

- [S-9.2] DCC Communications Standard
- [S-9.2.1] DCC Extended Packet Formats -
- [RCN-212] DCC operating commands for vehicle decoders
- [RCN-213] Operation commands for accessory decoders
- [S-9.2.1.1] DCC Adv Extended Packet Formats -
- [RCN-218] DCC-A-automatic registration

1.3 Terminology

Term	Definition
HOST	Main module which generate the SUSI Clock
SUSI-Module	Extension module, controlled by the Host

1.4 Requirements

To comply with this standard, the specifications and commands defined here must be respected. The basic specifications described in [S-9.4.1 / RCN-600] must be applied. It is not necessary to support all commands of the interface. This applies to both Hosts and Modules. The description of the respective product should list the usable / necessary functions.

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3 Document History

Date	Description
2025.07.02	First Draft

4 Particularities compared to RCN-600

With SUSI-BiDi, similarly max. 3 Modules can be operated by one Host. The Host regularly calls all registered Modules to enable them to respond. If data is available, the Modules responds to its BiDi call with an acknowledge ("ACK"). The Host then generates 32 clocks to read the message from the Modules. Since the BiDi messages are sent on the normal data line, they can be read directly by the Host and also by other Modules. A BiDi message always consists of two times two bytes (4 bytes). In the 1st and 3rd byte special BiDi identifiers are sent in order to maintain compatibility with the usual SUSI 2-byte commands. For other Modules, these are special command bytes. Modules without SUSI-BiDi ignore these unknown commands. In byte 2 and 4 the data bytes belonging to the BiDi identifier are transmitted.

- The data line must always be on receive mode after a BiDi call (pull-up active).
- After each BiDi call, a 4 to 5 ms pause must be used as a response window.

5 Protocol

After a restart/reboot, the 3 BiDi Modules are interrogated by the Host with special BiDi commands. Connected BiDi Modules must always answer (report) to these. Those Modules which answer (report), are considered thus in the Host as registered (announced). If a Module has no meaningful data to send, the function-empty command is sent two times.

During operation, the Host must call each registered BiDi Module at least every 100 ms. If response data is available, the BiDi Module issues a 1 to 2 ms long "ACK" pulse at the latest 2 ms after the last falling edge. The Host must accept "ACK" pulses with at least 0.5 ms length as valid.

As soon as the "ACK" has been cleared by the Module, the Host sends 32 clocks in the normal time cycle. The Host only outputs the clock and leaves the data line in receive mode.

After each rising clock edge, the Module places its data bit on the bus.

With each falling edge, the Host (and possibly other Modules) reads the bit.

The Module releases its data from the data line 10 to 500 µs after the last negative edge and switches it to input. When reading a block, the Module only switches the data line back to input if no further clock is read within 50 µs or it has already sent the checksum.

The Host must pause for 1 to 1.5 ms after the last negative edge before sending a new command. There are no breaks when reading a block and the clocks follows each other directly.

A SUSI BiDi Module must always respond to a CV read command if the requested CV is in its CV range, even if it does not use it! A response with 0x8E + 0x01 (ERR 'not supported') is also permitted.

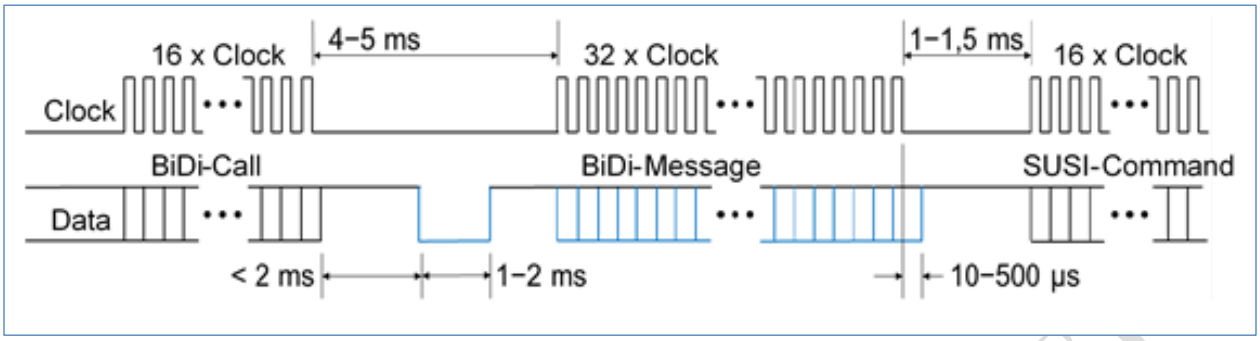

Figure 1: Timing diagram

In Figure 1 the time sequence of a bidirectional transmission is illustrated. The blue pulse and the blue data are generated by the Modules.

5.1 CV bank reading

To read an entire CV bank, a special procedure is used to make the transmission faster and more secure.

The special CV bank read command, which is available individually for each Module, is used for the transfer. This means that the Module can be selected, the bank which will be read can be defined and the data transfer can be started with one command. The read procedure always starts at the beginning of the bank, i.e. at CV 900, 940 or 980. This command works independently of the bank number stored in CV 1021 and this CV is not altered.

After the command, the Host expects an ACK which is signaling that the Module has understood the command and the selected bank is supported. The Host then sends 32 clocks multiple times, during which the Module transmits the sequence: the BiDi command 0x8F, one data byte, the BiDi command 0x8F, one data byte. This is typically done twenty times to transfer all 40 bytes of a bank. If the Module in a bank only has a small amount of data, it can abort the transmission by sending both bytes or just the second byte with 0x8E for CV not present.

Regardless of whether all 40 bytes have been sent or the transmission was aborted, 32 clock cycles are then sent for a checksum. The first byte contains a CRC checksum, and the second byte contains the value 0. This is only transmitted to maintain the usual BiDi transmission of byte pairs (here we should have the same structure CMD, 1 byte = CRC, CMD, 1 byte = 0).

The checksum is calculated as described in [RCN-218] Section 1.3. On the transmitter side, it is calculated according to polynomial x8 + x5 + x4 + 1 over all data bytes sent including the bytes sent with the BiDi command 0x8E, initialized with 0, not inverted. On the receiver side, the CRC is calculated with the same polynomial over all CVs including CRC; the result must be 0. Examples, informative notes and algorithm suggestions can be found in Appendix C of [RCN-218].

When reading a CV bank, the following steps are carried out:

Host: The Host sends 0x0C – <Bank#> = Bank Read command for Module 1.

Module: The Module responds with an “ACK” if the bank is available. Without ACK, reading is aborted here.

Module: The Module sends two bytes per 32 cycles as 0x8F + CV value. This usually happens twenty times. Optionally, to abort the read operation prematurely:

Module: The Module sends 0x8F + CV value + 0x8E + 0x01 (ERR 'not supported') or

Module: The Module sends 0x8E + 0x01 (ERR) + 0x8E + 0x01 (ERR). Both will prematurely abort further data reading.

Module: The Module sends checksum as 0x8F + checksum + 0x8F + 0x00

Then the Host must keep a 9ms long break so that all Modules can safely synchronize for the following SUSI command. Up to this point, 1 + 20 x 2 +2 = 43 commands without a break/pause were sent. The most important SUSI standard commands should be transmitted before reading another block.

6 Commands (Host calls)

Each BiDi Module call consists of 2 bytes. The 0x0# range is reserved for call commands.

Command	**Header**	**Data (Bit 7..0)**	**Comment**
Bidi Modules call	0x01	Bit 1 & 0 = Modules number	01 = 1, 10 = 2, 11 = 3
		Bit 2 = forced answer	With Bit 2 = 1, the Modules must answer with a status 0x8A.
		Bit 4 & 3 = status address	Selection of one of the four different status bytes (0x8A).
		Bit 7 .. 5 = reserved	
CV Bank Read from Module 1	0x0C	Bank No. Values 0 to 255	To transfer an entire CV bank from Module 1
CV Bank Read from Module 2	0x0D	Bank No. Values 0 to 255	To transfer an entire CV bank from Module 2
CV Bank Read from Module 3	0x0E	Bank No. Values 0 to 255	To transfer an entire CV bank from Module 3
Read CV	0x0F	CV-Nr. – 769	Modules only respond to inquiries from their own CVs according to [RCN-600] Table 1.

Table 1: BiDi commands (Host call)

7 BiDi messages (BiDi Module responses)

Each BiDi message consists of 4 bytes, which can be divided into 2 independent responses with 2 bytes each. Byte 1 and 3 are header bytes, Byte2 and 4 are data bytes. The range 0x80 to 0x8F is reserved for BiDi messages.

The position address mentioned in the table is an accessory decoder address. This accessory decoder address can be used, for example, by a transmitter module on the track (layout) to report its position (as an address) by a vehicle running above it. The matching receiver can be implemented as a SUSI BiDi module and pass on the received address as a position message to the Host and other Modules. This can be used, for example, for location-based station announcements in a sound module.

- The position address is sent in pairs: Byte1 & 2 = high, Byte 3 & 4 = low.
- The CV read response is sent in pairs: Byte1 & 2 = value (CV no.), Byte 3 & 4 = value (CV no.+1). Note: If e.g. CV 939 is read at Module 1, the automatic access to CV 940 leads to an error, which is transmitted as 0x8E 0x02.

All not defined values are reserved!

Command	**Header**	**Data (Bit 7..0)**	**Comment**
Signal state	0x80	0 = stop (HP0) 4 = slow travel (HP2) 15 = trip (HP1)	Based on NEM 672
Function directly	0x81	0 = no function 1 = sound: whistle / horn (variant 1) 2 = sound: whistle / horn (variant 2) 3 = sound: bell 4 = Sound: station announcement v1 5 = Sound: station announcement v2 6 = Sound: station announcement v3 7 = sound: level crossing bell 15 = Sound: Customer specific 16 = lighting 17 = shunting light 19 = evaporator on / off 24 = sound on / off 25 = reduced volume	Data = 0: empty command Not all combinations are meaningful or permitted. The combination 0 + 32 = 32 is not permitted. The combination 0 + 64 = 64 means all functions off, i.e. according to the specification via the protocol on the track.
		+0 = impulse (end automatically) +32 = switch on +64 = switch off	

Command	Header	Data (Bit 7..0)	Comment
Function value (DCC)	0x82	0 = DCC light function 1..28 = DCC function 1..28 +0 = impulse (end automatically) +32 = switch on +64 = switch off	Not all combinations are meaningful and allowed.
Short binary states	0x83	Definition according to [RCN-212] Section 2.3.5, encoded as **DLLL-LLLL** with **D** as binary state and **LLL-LLLL** for the number of the Binary state.	
Automatic speed	0x84	Speed step and direction as in 128 Speed step command according to [RCN-212] Section 2.2.2, encoded as **RGGG-GGGG** with **R** as the direction bit and **GGG-GGGG** for the Speed.	
Automatic operation	0x85	0 = stop 2 = travel (in the same direction) 4 = forward travel (shuttle travel) 6 = backward travel (shuttle travel) +1 = slow speed level	Unused values reserved
Test function	0x87	0 … 255	Reserved Massoth
Position address high	0x88	Bit2..0 = A10 .. 8 +0 = address [RCN-213] standard +8 = address [RCN-213] extended (ext)	The address ranges defined so far refer to accessory addresses. These are displayed linearly and not inverted, as shown in Table 3.
Position address low	0x89	A7 .. 0	

Command	Header	Data (Bit 7..0)	Comment
Status byte	0x8A	One of the four different status bytes: Status 0: Bit 0 = 1: Motor control enabled (sound upgrade completed) Bit 1 = 1: Light function enabled (e.g., generator sound for steam locomotive running) Bit 4 = 0/1: Boiler fire simulation off/on (synchronized with coal shovel sound) Status 1: Bit 0 = 1: Another vehicle is coupled to the front. Bit 1 = 1: Another vehicle is coupled to the rear. All other bits in status 0 and 1 are reserved for future use. Status 2 and 3: Reserved for future use.	Only the first two status bytes (status 0 and 1) may be sent spontaneously. The remaining two bytes are only sent in response to a BiDi-SUSI module call with bits 2 and 3 (address) set. Status 0 is always sent first, followed by status 1, or status 2 is sent first, followed by status 3. If a status is not implemented, the empty command 0x81 0x00 is sent instead.
Analog values A	0x8C	Analog channel 1 and, if applicable, analog channel 2, each with 8 bit resolution. If two analog values with identifier 0x8c are sent in a BIDI message, analog channel 1 is transferred first and then analog channel 2	
Analog values B	0x8D	Analog channel 3 and, if applicable, analog channel 4, each with 8 bit resolution. If two analog values with identifier 0x8c are sent in a BIDI message, analog channel 3 is transferred first and then analog channel 4	
CV response: Invalid value	0x8E	0x00 = unknown error 0x01 = CV not supported 0x02 = CV number invalid	CV is not implemented in the Modules CV number invalid for the Modules number
CV response: value valid	0x8F	0 … 255	

Table 2: Arrangement of the bits of the position address

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