D21008-1

Technical documentation

Communication Board

COM-FSE101

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Masthead

This documentation is the translation of the German original.

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With your comments and suggestions you assist us in our intention to continuously improve the quality and practical relevance of the documentation.
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Thank you for your feedback.

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Review list

Version	Date	Prepared by	Sections modified	Modifications
1	2016-09-19	Anita Ecker	all	initial version

Translation list

Version	Date	Prepared by	Sections modified	Modifications
1	2016-09-19	Anita Ecker	all	initial English version

Bibliography

D-Number	Title	Version[1]
D21001	System documentation Frauscher Advanced Counter FAdC R2	2
D21010	Checklist for SABs COM-FSE101 for FAdC R2	2

D-Number	Title	Version
D3487	Protocol specification Frauscher Safe Ethernet (FSE), Protocol Version 2.1	4
D3852	Specification Application Data Version 1 Frauscher Safe Ethernet (FSE)	1.1
D4014	Application data Communication between Interlocking and Frauscher Advanced Counter Release 2	6

List of standards

Number	Title	Issue/ version
EN 50159	Railway applications – Communication, signalling and processing systems – Safety-related communication in transmission systems	2010

1 The stated or a higher version is valid.

1 About this documentation

This documentation provides information for the communication board COM-FSE101 and describes the prerequisites for project planning regarding the COM-FSE101 within the Frauscher Advanced Counter FAdC R2.

This documentation is an addition to the documentation D21001 “System documentation Frauscher Advanced Counter FAdC R2”. Therefore, also the contents of the system documentation must be observed.

The communication board COM-FSE101 is to be used with the system FAdC R2. The type “101” describes this assignment to FAdC R2. In the following, the COM-FSE101 is only referred to as COM-FSE for simplification.

In the documentation D21001 “System documentation Frauscher Advanced Counter FAdC R2”, COM-xxx is used as a generic term to describe any protocol-specific COM board. That means that all the details and specifications regarding the COM-AdC/COM-xxx also apply to the COM-FSE and must be taken into account.

1.1 Typographical conventions

The following typographical conventions are applied in this documentation:

1.1.1 Pictograms

Safety-related application conditions (SAB)

Safety-related application conditions define rules, conditions and restrictions, which must be observed and complied with by the user and/or by the subsequent system in the life cycle phases after the development. Only by this, a safe and fault-free operation can be ensured.

Safety-related application conditions are shown as follows:

SAB number:

Description

The SAB number is a number assigned by Frauscher to uniquely identify an SAB. The SAB numbers are not consecutive in the documentation.

Symbol and text indicate situations or incorrect operations that could immediately endanger human

life and/or product.

Important notes

Important notes contain information and instructions regarding the availability and the safe operation of the system.

Important information and notes are shown as follows:

 Description

Recommendations and tips

Recommendations and tips contain information, which facilitate the handling of the system for the user.

Recommendations and tips are shown as follows:

 Description

1.1.2 Styles of writing and other formal principles

Orders

- Contents (descriptions, figures, tables etc.) are generally described in this documentation “from left to right” and “from top to bottom”.

Numbers

- Decimal places of decimal numbers are separated by a comma (,) (e.g.: 123,45).
- For reasons of better readability, digits of four- or multi-figure decimal numbers are arranged from right to left with thousands separators in groups of three digits (e.g. 1 234).

Bits and bytes

- Bits and bytes are numbered beginning with ‘0’.
- The LSB (least significant bit) is always on the right, the MSB (most significant bit) is always on the left. This also applies in case several consecutive bytes are transmitted.

Bit no.	7	6	5	4	3	2	1	0
Binary number	1	0	0	1	0	1	1	0
Bit significance	MSB							LSB

Table 1.1: LSB and MSB of an 8-bit number

Bit no.	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Binary number	1	0	0	0	1	0	1	0	1	1	0	0	1	1	0	0
Bit significance	MSB							LSB	MSB							LSB

Table 1.2: LSB and MSB of a 16-bit number

Ellipsis

An ellipsis (“…”) designates text parts, single words or figures and/or ranges of figures, which are left out. It is used to depict contents in a short form.

Examples for an ellipsis in case of a range of figures:

0
…
15

In this example, the range of figures from 0 to 15 is depicted. The ellipsis represents the figures 1 to 14.

b11 … b0

In this example, the range of figures (binary) from 0 to 11 is depicted. The ellipsis represents the figures b1 to b10.

1.2 Units of measurement

In this documentation the following units of measurement are used:

B	byte (1 B = 8 bit)
B/s (= Bps)	byte per second
bit	bit
m/s	metre per second
mm	millimetre
ms	millisecond
s	second

1.3 Abbreviations

In this documentation the following abbreviations are used:

0b	prefix of a binary number
AEB	Advanced Evaluation Board
ASD	Advanced Service Display
BP-PWR	Backplane for Power Supply
CAN	Controller Area Network (serial bus system)
COM	Communication board (generic term for the different communication boards)
COM-AdC	Communication board for Advanced Counter
COM-FSE	Communication board with implemented FSE protocol (specific communication board COM-xxx with implemented FSE protocol)
COM-FSE101	Communication board with implemented FSE protocol, type 101 (specific communication board COM-xxx with implemented FSE protocol)
COM-xxx	Communication board (generic term for a specific communication board with vital software interface)
CRC	cyclic redundancy check (checksum)
d	diameter
DIP	Dual In-line Package (DIP-switch)
EN	European standard
FAdC	Frauscher Advanced Counter
FAdC R1	Frauscher Advanced Counter, Release 1
FAdC R2	Frauscher Advanced Counter, Release 2
FDS	Frauscher Diagnostic System
FMA	track section, synonyms: counting circuit, counting section
FSE	Frauscher Safe Ethernet
FWD	forwarding

ID	identifier
IEC	International Electrotechnical Commission
I/O	input/output
IO-EXB	Input/Output Board
IP	Internet Protocol
IXL	interlocking
LED	light-emitting diode
LSB	least significant bit
MSB	most significant bit
RSR	wheel sensor
RSR180	wheel sensor, type RSR180
RSR123	wheel sensor, type RSR123
SAB	safety-related application condition
Sys	system of a wheel sensor
Sys1	sensor system 1
Sys2	sensor system 2
UDP	User Datagram Protocol
v	speed

1.4 Terms and definitions

damped	One or two sensor system(s) of a wheel sensor indicate(s) an occupancy (generally in the case of traversing by a train wheel and/or when damped by a testing plate).
occupied	Status of the axle counting system if at least one sensor system is damped or if one or more axles are located in the track section (FMA).
clear	Status of the axle counting system after a successful reset or if all axles counted into the track section (FMA) have been counted out again and there is no fault.
clearing of track	In the case of clearing of track, at least two axles must be counted in and/or out at one or two different counting heads, depending on the configuration. The clearing of track is generally part of the reset procedure.
track section (FMA)	Section of track between the counting heads belonging to an axle counting system. This may be a track, a set of points, an intersection, a line or a combination of these elements. Synonyms: counting circuit, counting section
reset	Procedure to bring a track section (FMA) into “clear” status.
reset restriction	Prevention of a reset due to technical (e.g. safety-relevant error) or operational (e.g. “last axle counted in”, “last axle counted out”) situations.
commissioning	Test on an item carried out on site, to prove that it is correctly installed and can operate correctly (IEC 60050-151-16-24).

maintenance, corrective	The maintenance carried out after fault recognition and intended to put an item into a state in which it can perform a required function (IEC 60050-191-07-08). Synonym: repair
maintenance, preventive	The maintenance carried out at predetermined intervals or according to prescribed criteria and intended to reduce the probability of failure or the degradation of the functioning of an item (IEC 60050-191-07-07). Synonym: servicing
repair	The maintenance carried out after fault recognition and intended to put an item into a state in which it can perform a required function (IEC 60050-191-07-08). Synonym: corrective maintenance
IO-EXB data	IO-EXB data transmission
last axle counted out	When a train passes over a track section (FMA) from inside to outside, axles are counted out. If the track section (FMA) was travelled over from inside to outside during the last counting procedure carried out, we talk of “last axle counted out”.
last axle counted in	When a train passes over a track section (FMA) from outside to inside, axles are counted in. If the track section (FMA) was travelled over from outside to inside during the last counting procedure carried out, we talk of “last axle counted in”.
partial traversing	Partial traversing signifies that one or both sensor system(s) of a wheel sensor are damped without complete traversing.
Reset/pre-Reset	reset inputs
failsafe status	Status which poses no danger, e.g. an occupied or fault status. In case of a communication fault, the receiver must put and/or enter the failsafe status.
safety system	Higher-ranking system, which processes the data of the system FAdC (e.g. interlocking, level crossing, etc.).

fault	An error that can be rectified with a configured reset procedure, provided that the fault is not present any more.
maintenance, servicing	The maintenance carried out at predetermined intervals or according to prescribed criteria and intended to reduce the probability of failure or the degradation of the functioning of an item (IEC 60050-191-07-07). Synonym: preventive maintenance
counting head	In functional terms, a counting head consists of a wheel sensor, an overvoltage protection board and an evaluation board.

1.5 Target group

This documentation is intended for project engineers with subject-specific knowledge regarding track clear detection systems and their construction.

2 Safety

2.1 General protective provisions

Components of Frauscher must be used in the original condition (= characteristics and functions as described in the respective documentation).
Only the settings described in the respective documentation may be carried out. Apart from that, arbitrary changes of the components are not permitted.
However, if changes of a component should be required, then Frauscher must be consulted in any case and in advance.

All operational protective provisions of the rail operator must be observed.

2.2 Safety-related application conditions for the COM-FSE

The safety-related application conditions (SAB) for the communication boards COM-AdC and COM-xxx, that are described in the documentation D21001 “System documentation Frauscher Advanced Counter FAdC R2”, also apply to the communication board COM-FSE, because the COM-FSE is a specific implementation of a COM-xxx.

In addition, all safety-related application conditions stated in this documentation apply to the COM-FSE.

SAB FAdC-FSE100_1:
If the COM-FSE101 is connected to a network according to EN 50159:2010, category 3, then additional protective measures (“cryptographic methods”) must be added.

2.3 Qualified personnel

Working on the system FAdC (mounting, commissioning, maintenance and repair work) must only be carried out by trained skilled personnel.

2.4 Safety-conscious working

- The operator is responsible for the occupational safety.
- The system may only be operated in proper condition.
- All actions carried out on the system must not impair the safety of people or the function of the system.
- No arbitrary alterations and modifications may be carried out on the system.

2.5 Intended use

The product is intended for a specific operation purpose described in the documentation. If applied outside the intended use described, in the case of non-compliance with the documentation or in the case of non-compliance with required prerequisites and safety measures, no warranty and/or liability shall apply.

3 COM-FSE with implemented FSE protocol

The communication board COM-FSE is able to communicate with various safety systems, which support the FSE protocol.

3.1 Delivery status of the COM-FSE

Before a COM-FSE is used, it must be configured according to the following documents:

- design and planning documents (e.g. track layout, network plan, etc.)
- documentation D21001 “System documentation Frauscher Advanced Counter FAdC R2”, chapter “Configuration”
- chapter “Configuration of the communication board COM-FSE” of this documentation

If requested and ordered by the customer, the COM-FSE can also be configured by Frauscher.

3.2 Pin coding on the BP-PWR for the COM-FSE

Since the COM-FSE is equipped with a type-dependent coding (= 5 drill holes on the male multipoint connector), the plug sockets on the backplane BP-PWR also need an appropriate pin coding. Thereto, 5 coding pins are inserted into the corresponding drill holes on the female multipoint connector on the BP-PWR.

The position of the single coding pins on the female multipoint connector depends on which board is plugged into the corresponding plug socket.

If the assignment of the plug sockets is already known when ordering, then the pin coding of the BP-PWR can be carried out by Frauscher prior to delivery if requested and ordered by the customer.

If the assignment of the plug sockets is not yet known when ordering, then the coding pins are delivered separately. In this case, the pin coding must be carried out by the user according to the following figure.

In the following figure, the position of the coding pins on the female multipoint connector of the BP-PWR is marked with a red dot.

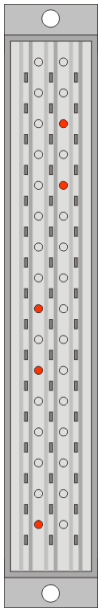

Figure 3.1: Pin coding on the BP-PWR for the COM-FSE101

It must be observed that the coding pins are not bent or broken.

3.3 Function of the COM-FSE

The hardware of the COM-FSE is identical with the hardware of the COM-AdC101 (see documentation D21001 “System documentation Frauscher Advanced Counter FAdC R2”).

In addition to the functionality of the COM-AdC101 (configuration server and data transmission within the FAdC), the COM-FSE can communicate with a safety system via Ethernet.

The COM-FSE contains the protocol implementation for the specific protocol of the safety system (FSE protocol, see documentation D3487 “Protocol specification Frauscher Safe Ethernet (FSE) Protocol Version 2.1”). Hence, it is possible to connect a safety system to the FAdC R2 via the FSE protocol.

There are 2 directions for messages:

- Messages that are sent from the communication board COM-FSE of the FAdC to the safety system.
- Messages that are sent from the safety system to the communication board COM-FSE of the FAdC.

3.3.1 Messages from the FAdC to the safety system

Messages from the FAdC to the safety system are a contiguous series of up to 8 types of information:

- checkbyte
- information on status of track section (FMA)
- current number of axles in a track section (FMA)
- indication of train length
- information on direction
- information on speed
- information on wheel diameter
- I/O information of the AEB/IO-EXB

SAB FAdC-FSE100_2:
Due to delays in case of data transmission from the system FAdC with COM-FSE101 to the safety system, a delay is possible when failsafe information such as clear indication, direction pulse or I/O data is output.
The maximum possible delay results from the sum of the configured time-outs of AEB, COM-FSE101 and safety system + 30 ms process time of the COM-FSE101.
It must be checked if due to the maximum possible delay period, the required safety objective can be reached.

The transmission interval for messages from the FAdC to the safety system can be configured (see configuration word “FSE transmission interval”).

In each case, the logical status ‘1’ represents the condition as described (see columns “Description” in the following tables). The logical status ‘0’ represents the negated described condition (“not …”). Unused bits are ‘0’.

3.3.1.1 Checkbyte

For the connection between the FAdC and the safety system, a checkbyte can be transmitted in the application data as shown in the following table. Unused bits (bits 0 to 4) are ‘0’.

Byte	Bit	Designation	Description	Bit = 0	Bit = 1	Failsafe
0	7	ACLB	axle counter loopback (bit ILLB, see chapter “Messages from the safety system to the FAdC”)	‘0’ was received at the safety system or time-out since the last reception at the safety system	‘1’ was received	no
	6	SR	successful reception at the safety system	time-out since the last reception at the safety system	successful reception at the safety system	no
	5	A1	always ‘1’	-	always ‘1’	no
	4	-				
	3	-				
	2	-				
	1	-				
	0	-				

Table 3.1: Structure of the checkbyte

The transmission of the checkbyte from the FAdC to the safety system can be configured (see configuration word “Application data addition”, entry “CHECK”).

If this checkbyte (FAdC to the safety system) is used, then the checkbyte for the other direction of communication (safety system to the FAdC) is set automatically.

3.3.1.2 Information on status of track section (FMA)

For each configured track section (FMA), 2 bytes with information on status of track section (FMA) are transmitted (see the following table and configuration word “Application data FAdC”). Only bit 7 (CLR) of byte 0 is failsafe (vital). For safety-related applications, only this bit 7 (CLR) of byte 0 from the information on status of track section (FMA) may be used. Unused bits (bits 0 to 3 of byte 1) are ‘0’.

Byte	Bit	Designation	Description	Bit = 0	Bit = 1	Failsafe
0	7	CLR	track section (FMA) clear	not clear	clear	yes
	6	OCC	track section (FMA) occupied	not occupied	occupied	no
	5	NZ	counter reading not equal to zero	zero	not zero	no
	4	RR	reset restriction	no reset restriction (last axle counted out)	reset restriction (last axle counted in)	no
	3	RAB	reset ability	reset not possible	reset possible	no
	2	WCT	waiting for clearing of track	clearing of track not necessary	waiting for clearing of track	no
	1	ERR	error in the track section (FMA)	no error	error	no
	0	PT	partial traversing	no partial traversing	partial traversing	no
1	7	CE	communication error[2]	no communication error	communication error	no
	6	RAC	reset accepted	reset not accepted or no reset	reset accepted	no
	5	RJO	reset rejected operationally	reset not rejected operationally or no reset	reset rejected operationally	no
	4	RJT	reset rejected technically	reset not rejected technically or no reset	reset rejected technically	no
	3	-				
	2	-				
	1	-				
	0	-				

Table 3.2: Structure of information on status of track section (FMA)

2 In case of communication error between AEB and the COM-FSE, which sends to the safety system, all the other bits in this information on status of track section (FMA) are ‘0’.

The bits CLR and OCC can occur in the following combinations:

CLR	OCC	Meaning
0	0	track section (FMA) faulty
0	1	track section (FMA) occupied
1	0	track section (FMA) clear
1	1	this combination cannot occur

Table 3.3: Combinations of bits CLR and OCC

If messages are transmitted from the FAdC to the safety system, then the internal process time of the COM-FSE of up to 30 ms must be observed.

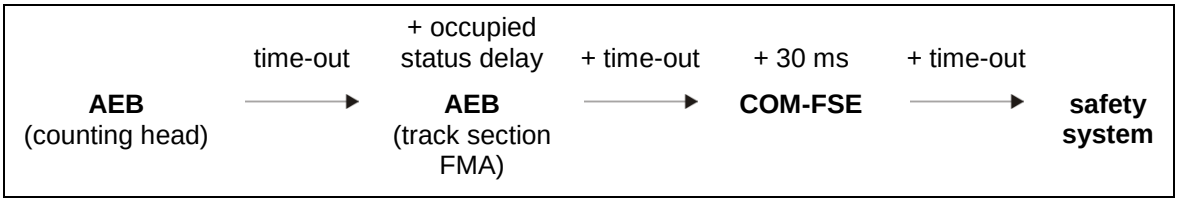

Figure 3.2: Maximum possible delay of messages from the FAdC to the safety system

3.3.1.3 Current number of axles in a track section (FMA)

For each configured track section (FMA), 2 additional bytes containing the current number of axles in a track section (FMA) can be transmitted in the application data. The structure of the current number of axles in a track section (FMA) is described in the following table:

Byte	Bit	Designation	Description	Notes	Failsafe
0	15 … 8	CATS	current number of axles in a track section (FMA)	The information is transmitted as signed integer. The information can be time-delayed to another change of status (clear or occupied) due to the internal protocol structure.	no
1	7 … 0				

Table 3.4: Structure of current number of axles in a track section (FMA)

The current number of axles in a track section (FMA) is transmitted immediately after the information on status of track section (FMA) for the respective track section (FMA). The current number of axles in a track section (FMA) is only transmitted for the track sections (FMA) for which this information was configured.

3.3.1.4 Indication of train length (total number of axles of a train)

For each configured track section (FMA), 2 additional bytes with the train length (total number of axles) of the train, which passed through a track section (FMA) recently, can be transmitted in the application data. The structure of the indication of train length is described in the following table:

Byte	Bit	Designation	Description	Notes	Failsafe
0	15 … 8	TL	indication of train length	The information is transmitted as signed integer. The information can be time-delayed to another change of status (clear or occupied) due to the internal protocol structure.	no
1	7 … 0				

Table 3.5: Structure of indication of train length

If a train moves into the track section (FMA), then the axles of the train which were already counted in are indicated. If the train has left the track section (FMA), then the total number of axles of this train is indicated, until the next train moves into the track section (FMA) or until the track section (FMA) changes into the status “faulty”. If the track section (FMA) is in the status “faulty”, then 0 axles are indicated. If the track section (FMA) is in the status “occupied”, then the number of axles which were counted into the track section (FMA) is indicated.

The train length of the train, which passed through the track section (FMA) recently, is transmitted immediately after the information on status of track section (FMA) and the current number of axles in a track section (FMA) (if used) for the respective track section (FMA). The train length is only transmitted for the track sections (FMA) for which this information was configured.

3.3.1.5 Information on direction

For each configured counting head, 1 byte with information on direction can be transmitted in the application data (see following table and configuration word “Application data FAdC”). In case one or more direction pulses (bits 4 to 7) are used for safety-related applications, bit 3 must be evaluated in each case and always used additionally. Unused bits (bits 0 to 1) are ‘0’.

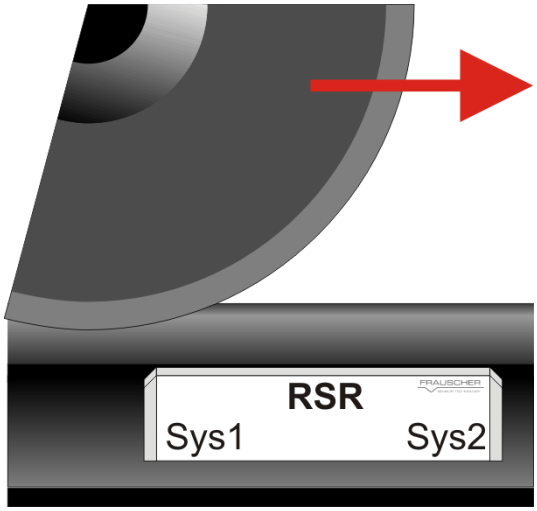

Figure 3.3: Traversing in direction 1

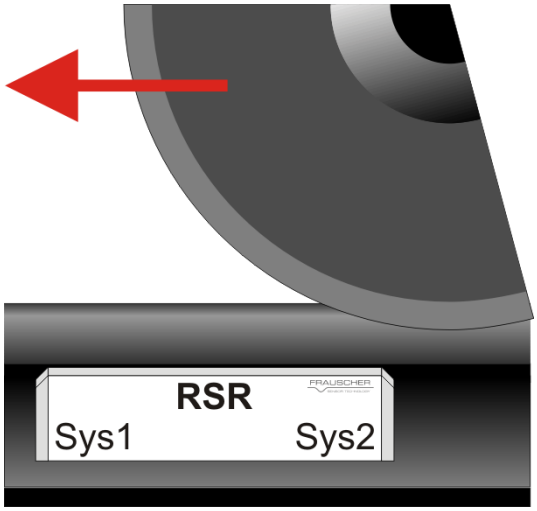

Figure 3.4: Traversing in direction 2

Byte	Bit	Designation	Description	Bit = 0	Bit = 1	Failsafe
0	7	N1E1	inverted (not) 1-edge direction pulse, direction 1	traversing in direction 1 or error	no traversing in direction 1	yes
	6	N1E2	inverted (not) 1-edge direction pulse, direction 2	traversing in direction 2 or error	no traversing in direction 2	yes
	5	4E1	4-edges direction pulse, direction 1	no traversing in direction 1 or error	traversing in direction 1	yes
	4	4E2	4-edges direction pulse, direction 2	no traversing in direction 2 or error	traversing in direction 2	yes
	3	NED	no error in information on direction	error: Traversing cannot be clearly determined. All direction pulses will be reset (= 0). Is also set in case a communication error occurs.	no error	yes
	2	CED	communication error in information on direction	no communication error	communication error	no
	1	-				
	0	-				

Table 3.6: Structure of information on direction

The 1-edge direction pulse is typically used for wheel detection, i.e. to determine if a wheel traverses a wheel sensor or not. The bit for the 1-edge direction pulse is also set to ‘0’ in case of an error.

The 4-edges direction pulse is typically used for applications, where information on direction of traversing is needed. The bit for the 4-edges direction pulse is set to ‘0’ in case of an error.

The 1-edge direction pulse is set to ‘0’ (or re-triggered) when a sensor system of the wheel sensor changes from “not damped” to “damped” or from “damped” to “not damped”. The 1-edge direction pulse can only be used to detect safely that there is no traversing. If the 1-edge direction pulse is set to ‘0’, then an error could be present, even if the error bit NED is still set to ‘1’.

A 4-edges direction pulse is set to ‘1’ (or re-triggered) when a wheel has fully and correctly traversed the wheel sensor.

The error bit NED is set to ‘0’ if an error regarding this counting head occurs. This also includes communication errors and partial traversing.

If the bits 4E1, 4E2 and NED are used, then all statuses (no traversing, traversing with information on direction and error) can be determined safely.

The information on direction is only transmitted for the counting heads for which this information was configured.

SAB FAdC-FSE100_7:
In safety-relevant applications, the output of the 1-edge direction pulse due to faults must not lead to a dangerous status.

SAB FAdC-FSE100_6:
In safety-relevant applications, the absence of the 4-edges direction pulse due to faults must not lead to a dangerous status.

SAB FAdC-FSE100_5:
In case direction pulses are used, the safety system must enter the failsafe status when the error bit “Error Direction” is output. The leaving of the failsafe status must be determined application-related.

If a wheel cannot be mounted on the originally planned side of track due to mounting specifications, but it must be changed to the opposite rail, then this changeover to the opposite rail can be balanced with the DIP-switch DIP no. 14 on the right hand side of the AEB circuit board (see documentation D21001 “System documentation Frauscher Advanced Counter FAdC R2”, chapter “DIP-switches of the AEB”). In this case, no further modifications of the configuration of the FAdC, the safety system or the protocol are necessary.[3]

3 A direction inversion is also possible by cross-bonding of the wiring of the sensor systems.

Behaviour of information on direction bits

In the following figures, “x” is used as a variable for the whole length of the direction pulse. The pulse length is composed of the direction pulse, which is output by the evaluation board AEB, and the direction pulse extension, which is added by the communication board COM-FSE (2 550 ms + configured direction pulse extension, see configuration word “Timing FAdC”). Because of delays during transmission, the pulse length can be shorter or longer than the sum of these 2 times (output of direction pulse + direction pulse extension).

Initial status:
In the initial status (no traversing, no error and system ready for operation) the direction pulses 4E1, N1E1, 4E2 and N1E2 are logic ‘1’. The error bit NED and the communication error bit CED are also ‘1’ in this status.

Correct traversing in direction 1

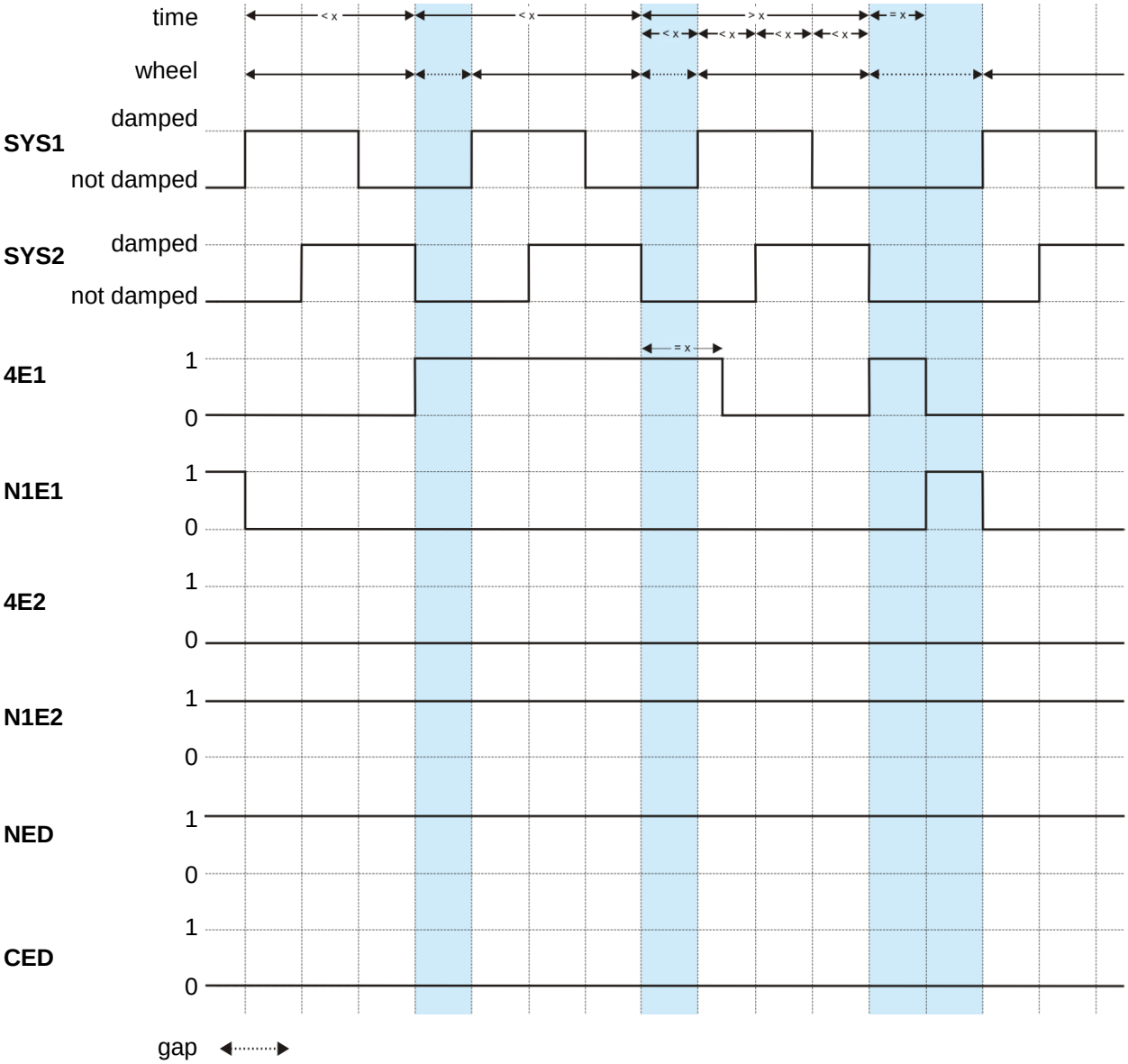

Figure 3.5: Correct traversing in direction 1

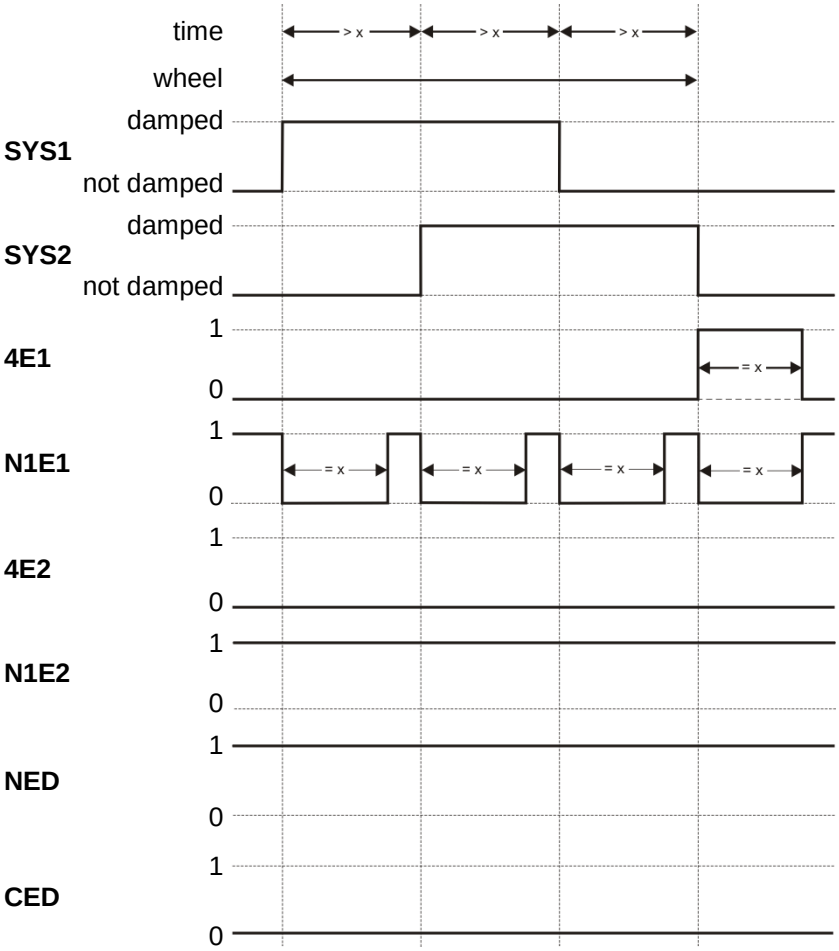

Figure 3.6: Correct traversing in direction 1 with low speed

The direction pulse 4E1 is output (changes from ‘0’ to ‘1’) at the end of the traversing in direction 1 for the duration of the pulse length, as soon as system 2 is not damped anymore. If the next wheel traverses the wheel sensor within the pulse length, then the direction pulse is extended by the direction pulse extension (re-triggering).
If the gap between 2 axles (between the two 4th edges of two traversings) is longer than the pulse length or the last axle traversed the wheel sensor, then the direction pulse 4E1 reverts to its initial status (logic ‘0’) after expiry of the pulse length. The pulse length starts after the 4th edge of the traversing.

In case of a correct traversing in direction 1, the direction pulse N1E1 is output (changes from ‘1’ to ‘0’) at the beginning of the traversing for the duration of the pulse length, as soon as system 1 is damped. If the next change of status of a wheel sensor (next edge of the signal) is within the pulse length, then the direction pulse is extended by the direction pulse extension (re-triggering).
If the gap between 2 changes of status is longer than the pulse length or the last axle traversed the wheel sensor, then the direction pulse N1E1 reverts to its initial status (logic ‘1’) after expiry of the pulse length.

In case of a correct traversing, the error bit NED is logic ‘1’.

The 4-edges direction pulse is output only in case of a correct traversing.

Correct traversing in direction 2

The direction pulse 4E2 is output (changes from ‘0’ to ‘1’) at the end of the traversing in direction 2 for the duration of the pulse length, as soon as system 1 is not damped anymore. If the next wheel traverses the wheel sensor within the pulse length, then the direction pulse is extended by the direction pulse extension (re-triggering).
If the gap between 2 axles (between the two 4th edges of two traversings) is longer than the pulse length or the last axle traversed the wheel sensor, then the direction pulse 4E2 reverts to its initial status (logic ‘0’) after the expiry of the pulse length. The pulse length starts after the 4th edge of the traversing.

In case of correct traversing in direction 2, the direction pulse N1E2 is output (changes from ‘1’ to ‘0’) at the beginning of the traversing for the duration of the pulse length, as soon as system 2 is damped. If the next change of status of a wheel sensor (the next edge of the signal) is within the pulse length, then the direction pulse is extended by the direction pulse extension (re-triggering).
If the gap between 2 changes of status is longer than the pulse length or the last axle traversed the wheel sensor, then the direction pulse N1E2 reverts to its initial status (logic ‘1’) after the expiry of the pulse length.

In case of a correct traversing, the error bit NED is logic ‘1’.

The 4-edges direction pulse is output only in case of a correct traversing.

Fault or partial traversing

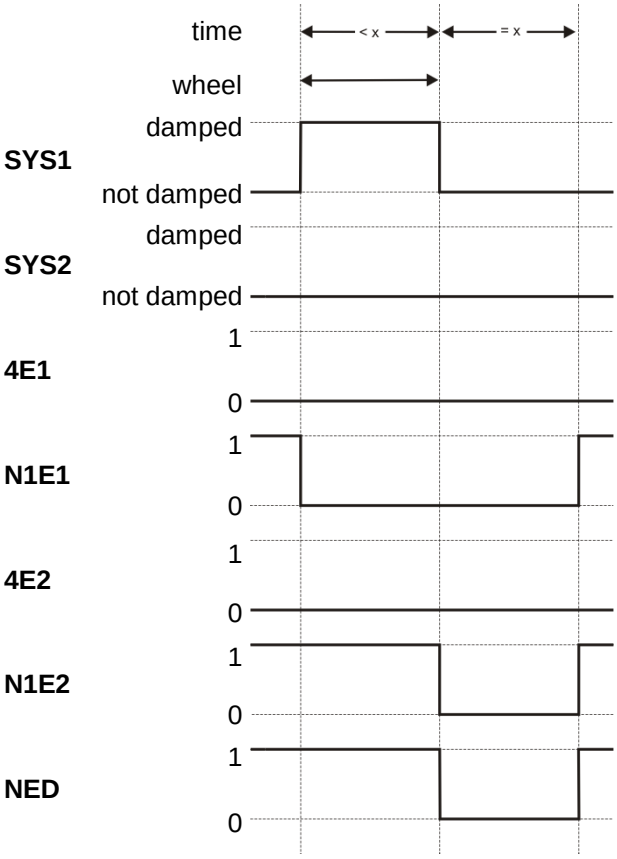

Figure 3.7: Partial traversing in direction 1

Both direction pulses N1E1 and N1E2 are output (bit = 0) in case of a fault (e.g. wire break, overcurrent, missing overlap, etc.) or partial traversing as well as in case of permanent system occupancy (> 10 s).

In case of a communication error (e.g. poor transmission quality, communication between AEB and COM-FSE interrupted), the communication error bit CED changes to ‘1’ until the fault is rectified.

The direction pulses N1E1 and N1E2 are output in any case (correct traversing, partial traversing or fault). The direction pulses 4E1 and 4E2 are not output in case of a fault (remain ‘0’ or are reset to ‘0’).
In case of a fault, the direction pulses N1E1, N1E2, 4E1 and 4E2 output logic ‘0’.
In case of a fault, the error bit NED changes to ‘0’ until the fault is rectified and the pulse length has run out. The pulse length starts at the point in time when the fault was rectified.
In case of a communication fault between AEB and COM, only the direction pulse extension is effective after the communication fault is rectified.

3.3.1.6 Information on speed

For each configured counting head, 5 bytes with information on speed can be transmitted in the application data. The structure of information on speed is described in the following table:

Byte	Bit	Designation	Description	Notes	Failsafe
0	7 … 0	RSR	wheel sensor type	1 = RSR180 3 = RSR123	no
1	31 … 24	SP	information on speed	time between the response of the 2 sensor systems resolution: (1/136 000 000) s The information can be time-delayed to another change of status (clear or occupied) due to the internal protocol structure.	no
2	23 … 16				
3	15 … 8				
4	7 … 0				

Table 3.7: Structure of information on speed

Speed calculation for wheel sensor RSR180:
For “SP”, fill in the bytes 1 to 4.

$$v = \frac{0{,}18 * 136\,000\,000}{SP} * k$$

The default value for the constant “k” for the RSR180 is 1 m/s. In order to optimise the constant “k”, detailed calculations can be carried out by the user.

Speed calculation for wheel sensor RSR123:
For “SP”, fill in the bytes 1 to 4.

$$v = \frac{(0{,}131 * 0{,}9808) * 136\,000\,000}{SP} * k$$

The value of the constant “k” for the RSR123 is 1 m/s. The constant “k” for the RSR123 was already optimised by Frauscher.

The information on speed is transmitted 1 time from the AEB to the COM-FSE. The COM-FSE transmits the data cyclically until the COM-FSE receives a new value from the AEB. The information on speed also contains the wheel sensor type. Prior to the first transmission from the AEB to the COM-FSE (= first traversing), the value of the wheel sensor type is set to ‘0’. After the first traversing, the respective value of the wheel sensor type is displayed. The information on speed is transmitted immediately after the information on direction for the respective counting head. The information on speed is only transmitted for the counting heads for which this information was configured.

3.3.1.7 Information on wheel diameter

For each configured counting head, 5 bytes with information on wheel diameter can be transmitted in the application data. The structure of information on wheel diameter is described in the following table:

Byte	Bit	Designation	Description	Notes	Failsafe
0	7 … 0	RSR	wheel sensor type	1 = RSR180 3 = RSR123	no
1	15 … 8	XVAL	x-value of information on wheel diameter	The relation YVAL/XVAL is proportional to the wheel diameter. It is always less than 1. The information can be time-delayed to another change of status (clear or occupied) due to the internal protocol structure.	no
2	7 … 0				
3	15 … 8	YVAL	y-value of information on wheel diameter		
4	7 … 0				

Table 3.8: Structure of information on wheel diameter

Wheel diameter calculation:

$$d = \frac{YVAL}{XVAL} * k$$

The constant “k” (stated in mm) is dependent on wheel sensor type and rail profile. It must be determined system-specific. At each change of wheel sensor type and/or rail profile, the constant “k” must be re-determined.

Reference values for the constant “k” in dependence of the wheel sensor and the rail profile:

Wheel sensor	Rail profile	“k” (reference value)
RSR180	S49	500 mm
	UIC60	540 mm
RSR123	S49	666 mm
	UIC60	655 mm

Table 3.9: Reference values for the constant “k”

The information on wheel diameter is transmitted 1 time from the AEB to the COM-FSE. The COM-FSE transmits the data cyclically until the COM-FSE receives a new value from the AEB. The information on wheel diameter also contains the wheel sensor type. Prior to the first transmission from the AEB to the COM-FSE (= first traversing), the value of the wheel sensor type is set to ‘0’. After the first traversing, the respective value of the wheel sensor type is displayed. The information on wheel diameter is transmitted immediately after the information on direction and information on speed for the respective counting head. The information on wheel diameter is only transmitted for the counting heads for which this information was configured.

3.3.1.8 I/O information of the AEB

For each AEB, 3 bytes with I/O information can be transmitted in the application data. The structure of the I/O information is described in the following table:

Byte	Bit	Designation	Description	Notes	Failsafe
0	7	ACIO23	I/O information of the AEB positions 23 … 16	24 data bits per AEB	yes
	6	ACIO22			
	5	ACIO21			
	4	ACIO20			
	3	ACIO19			
	2	ACIO18			
	1	ACIO17			
	0	ACIO16			
1	7	ACIO15	I/O information of the AEB positions 15 … 8		
	6	ACIO14			
	5	ACIO13			
	4	ACIO12			
	3	ACIO11			
	2	ACIO10			
	1	ACIO09			
	0	ACIO08			
2	7	ACIO07	I/O information of the AEB positions 7 … 0		
	6	ACIO06			
	5	ACIO05			
	4	ACIO04			
	3	ACIO03			
	2	ACIO02			
	1	ACIO01			
	0	ACIO00			

Table 3.10: Structure of the I/O information of the AEB

If messages are transmitted from the FAdC to the safety system, then the following times must be observed:

- the time of up to 32 ms until the AEB has read in the I/O data
- the internal process time of the COM-FSE of up to 30 ms

Figure 3.8: Transmission times of messages from the FAdC to the safety system

The I/O information of the AEB is only transmitted for the AEB boards for which this information was configured. The output of the I/O information is not extended by the AEB or the COM. The external system is responsible to set the failsafe status ‘0’ (error, communication error and fault) long enough so that the transmission of the failsafe status to the safety system is guaranteed.

SAB FAdC-FSE100_9:

If the failsafe status (input signal = low) of the I/O data is transmitted from the COM-FSE101 to the safety system, then this status must apply at the input of the system FAdC at least for the duration of the sum of the configured time-outs (AEB, COM-FSE101, safety system) + 30 ms (process time COM-FSE101). This ensures that the failsafe status of the I/O data is transmitted to the safety system.

3.3.2 Messages from the safety system to the FAdC

Messages from the safety system to the FAdC are a contiguous series of up to 3 types of information:

- checkbyte
- reset information
- I/O information of the safety system

The application data contain the checkbyte at first, then the reset information and then the I/O information of the safety system. The bytes necessary for this are arranged immediately one after another. The order of the affected reset information must be identical with the order of the track sections (FMA) for the transmission of messages from the FAdC to the safety system (see chapter “Messages from the FAdC to the safety system”). The order is determined during the configuration (see configuration word “Application data FAdC”). The failsafe status for all failsafe bits is ‘0’. Unused bits must be set to ‘0’.

Messages from the safety system to the FAdC must not contain any other information except checkbyte, reset information and I/O information of the safety system.

SAB FAdC-FSE100_3:

So that the safety system can evaluate and generate FSE messages correctly, the following specifications must be observed and their compliance must be proved:

- D3487-4 “Protocol specification Frauscher Safe Ethernet (FSE) Protocol Version 2.1”
- D4014-6 “Application data Communication between Interlocking and Frauscher Advanced Counter Release 2”

If the COM-FSE101 is operated in the compatibility mode, then the document D3852-1.1 “Specification Application Data Version 1 Frauscher Safe Ethernet (FSE)” must be observed and its compliance must be proved, instead of the document D4014-6.

3.3.2.1 Checkbyte

For the connection between safety system and FAdC, a checkbyte can be transmitted in the application data as shown in the following table. Unused bits (bits 0 to 6) must be set to ‘0’.

Byte	Bit	Designation	Description	Bit = 0	Bit = 1	Failsafe
0	7	ILLB	safety system loopback	‘0’ is sent	‘1’ is sent	no
	6	-				
	5	-				
	4	-				
	3	-				
	2	-				
	1	-				
	0	-				

Table 3.11: Structure of the checkbyte

The transmission of the checkbyte from the safety system to the FAdC can be configured (see configuration word “Application data addition”, entry “CHECK”).

If this checkbyte (safety system to the FAdC) is used, then the checkbyte for the other direction of communication (FAdC to the safety system) is set automatically.

In case of proper communication, the status of the bit ILLB is sent back to the safety system as bit ACLB in the checkbyte of the COM-FSE.

3.3.2.2 Reset information

For each configured track section (FMA), 1 byte with reset information must be transmitted in the application data. The status, described in the following table, is applicable if the relevant bit is set to ‘1’. Unused bits (bit 0) must be set to ‘0’.

Byte	Bit	Designation	Description	Bit = 0	Bit = 1	Failsafe
0	7	PRST	pre-Reset	pre-Reset is not carried out	pre-Reset is carried out	yes
	6	RST	Reset	reset is not carried out	reset is carried out	yes
	5	DRST	direct reset	direct reset is not carried out	direct reset is carried out	yes
	4	RRST	restricted reset	restricted reset is not carried out	restricted reset is carried out	yes
	3	RSTR	reset restriction can-celled	reset restriction is not cancelled	reset restriction is cancelled	yes
	2	PDRST	preparatory direct reset	preparatory direct reset is not carried out	preparatory direct reset is carried out	yes
	1	PRRST	preparatory restricted reset	preparatory restricted reset is not carried out	preparatory restricted reset is carried out	yes
	0	-	-	-	-	-

Table 3.12: Structure of reset information

Sequence for a reset procedure via protocol

If a reset procedure is carried out via protocol, then the following sequence must be observed:

- It must be checked if the bits RAC, RJO and RJT of the respective track section (FMA) are ‘0’ and if the bit RAB is ‘1’.
- The respective bit of the reset information must be set to ‘1’.
- It must be waited until the reset of the associated track section (FMA) is accepted (RAC = ‘1’) or rejected (RJO = ‘1’ or RJT = ‘1’). If this is not the case within a few seconds, it must be continued with the next step.
- The reset bit must be set to ‘0’.
- It must be waited until the bits RAC, RJO and RJT are ‘0’.

If a reset consists of multiple steps (e.g. (pre-Reset + Reset)), then the sequence for a reset procedure via protocol must be used several times one after another.

Only 1 bit per track section (FMA) may be set to ‘1’ at the same time.

3.3.2.3 I/O information of the safety system

For the connection between the safety system and the FAdC, I/O information can be transmitted in the application data. The structure of the I/O information of the safety system is described in the following table:

Byte	Bit	Designation	Description	Notes	Failsafe
0	7	ILIO23	I/O information of the safety system positions 23 … 16	-	yes
	6	ILIO22			
	5	ILIO21			
	4	ILIO20			
	3	ILIO19			
	2	ILIO18			
	1	ILIO17			
	0	ILIO16			
1	7	ILIO15	I/O information of the safety system positions 15 … 8		
	6	ILIO14			
	5	ILIO13			
	4	ILIO12			
	3	ILIO11			
	2	ILIO10			
	1	ILIO09			
	0	ILIO08			
2	7	ILIO07	I/O information of the safety system positions 7 … 0		
	6	ILIO06			
	5	ILIO05			
	4	ILIO04			
	3	ILIO03			
	2	ILIO02			
	1	ILIO01			
	0	ILIO00			

Table 3.13: Structure of I/O information of the safety system

If messages are transmitted from the safety system to the FAdC, then the following times must be observed:

- the internal process time of the COM-FSE of up to 30 ms
- the time of up to 32 ms until I/O data are output by the AEB

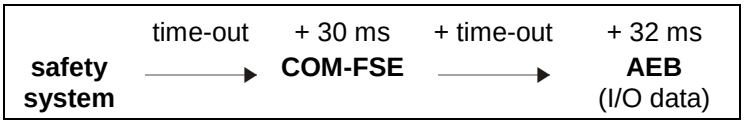

Figure 3.9: Transmission times of messages from the safety system to the FAdC

The transmission of the I/O information from the safety system to the FAdC must be configured (see configuration word “Application data addition”, entry “DATA_TO_FADC”). The output of the I/O information is not extended by the COM. The safety system is responsible to set the failsafe status ‘0’ long enough so that the transmission of the failsafe status via the COM-FSE to the AEB is guaranteed.

The I/O information of the safety system is sent within the FAdC with the ID of the COM-FSE101.

SAB FAdC-FSE100_10:
If the failsafe status (input signal = low) of the I/O data is transmitted from the safety system to the COM-FSE101, then the safety system must transmit this status for the duration of the sum of the configured time-outs (AEB, COM-FSE101, safety system) + 30 ms (process time COM-FSE101). This ensures that the failsafe status of the I/O data is output by the system FAdC.

SAB FAdC-FSE100_11:
Due to delay in case of data transmission from the safety system to the system FAdC with COM-FSE101, a delay is possible when I/O data are transmitted.
The maximum possible delay is limited with the respective configured time-out (AEB, COM-FSE101 and safety system) + 30 ms (process time COM-FSE101).
It must be checked if due to the configured time-out, the required safety objective can be reached.

3.4 Performance parameters of the COM-FSE

A COM-FSE can evaluate data from up to 40 AEB boards. Following application data can be transmitted:

- checkbyte
- information on status of track section (FMA)
- current number of axles in a track section (FMA)
- indication of train length
- information on direction
- information on speed
- information on wheel diameter
- I/O information of the AEB/IO-EXB
- reset information
- I/O information of the safety system

The maximum number of bytes for application data at the sending side (messages from the FAdC to the safety system) is 201 bytes and consists of:

Number	Content	Length
1 x	checkbyte	1 byte
up to 40 x*	information on status of track section 1 (FMA 1)	2 bytes each
up to 40 x*	information on status of track section 2 (FMA 2)	2 bytes each
up to 80 x*	current number of axles in a track section (FMA) (for FMA 1 and FMA 2)	2 bytes each
up to 80 x*	indication of train length (for FMA 1 and FMA 2)	2 bytes each
up to 40 x*	information on direction	1 byte each
up to 40 x*	information on speed	5 bytes each
up to 40 x*	information on wheel diameter	5 bytes each
up to 40 x*	I/O information of the AEB	3 bytes each
* The maximum number of bytes for the application data is 200 bytes without checkbyte and must not be exceeded.		

Table 3.14: Division of bytes for application data at the sending side

The maximum number of bytes for the application data at the receiving side (messages from the safety system to the FAdC) is 84 bytes and consists of:

Number	Content	Length
1 x	checkbyte	1 byte
40 x	reset information track section 1 (FMA 1)	1 byte each
40 x	reset information track section 2 (FMA 2)	1 byte each
1 x	I/O information of the safety system	3 bytes

Table 3.15: Division of bytes for application data at the receiving side

The minimum interval for sending messages is 100 ms.

The minimum permitted interval for processing data, which are received by the COM-FSE from the safety system, is 100 ms.

If data are forwarded to the CAN bus or evaluated for the transmission to the safety system, then the following restrictions apply:

Data transmission	Transmission interval AEB boards			
	10 ms	40 ms	80 ms	160 ms
number of the participants on the CAN bus	10	40	80	80
number of the AEB boards which are received via “Ethernet FWD internal”	7	30	30	30
number of the AEB boards which are received via „Ethernet FWD internal” with multicast	5	20	20	20
sum of the participants on the CAN bus and of the AEB boards which are received via “Ethernet FWD internal”	10	40	80	110
number of the AEB boards which are transmitted for evaluation to the safety system via “Ethernet safety system”	10	40	40	40
forwarding of the AEB boards from CAN bus to “Ethernet FWD internal”	5	20	20	20
forwarding from CAN bus to “Ethernet FWD internal” (data are transmitted twice)	2	10	10	10
forwarding from “Ethernet FWD internal” to CAN bus	5	20	20	20

Table 3.16: Maximum number of the AEB boards depending on data transmission and configured transmission interval

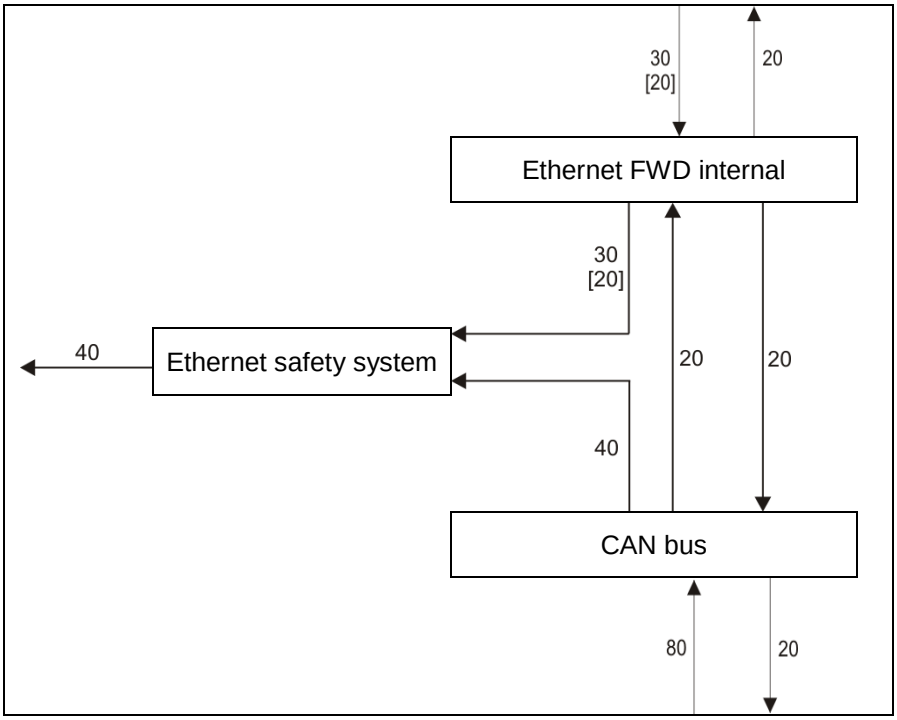

Figure 3.10: Transmission paths of the COM-FSE with maximum possible number of AEB boards[4], depending on data transmission and configured transmission interval

The data received via Ethernet including timestamp requests may come from a maximum of 100 boards.

Timestamp requests are sent from boards, for which the entries “SLCT_TIMEOUT” and “ID” were configured in the respective configuration word.

It must be observed that all AEB boards, which were configured to evaluate I/O data of a COM-FSE, are sending timestamp requests to the respective COM-FSE boards. A COM-FSE which evaluates FSC data of an AEB also sends timestamp requests to the respective AEB boards.

4 The numbers in the brackets are the maximum possible AEB boards in case of data transmission with multicast.

Following configuration words of the AEB contain the entries “SLCT_TIMEOUT” and “ID”:

- Counting head FMA 1
- Counting head FMA 2
- Supervisor section for FMA 1
- Supervisor section for FMA 2
- Synchronisation FMA 1
- Synchronisation FMA 2
- Counting Head Control

The configuration word “Application data FAdC” of the COM-FSE also contains the entries “SLCT_TIMEOUT” and “ID”.

3.5 Bandwidth requirement for the FSE interface

The bandwidth requirement for the FSE interface can be calculated with the following formula:

$$\text{Bandwidth requirement [B/s]} = \frac{1\,000}{\text{FSE interval [ms]}} * (\text{complete overhead [B]} + \text{application data [B]})$$

FSE interval:	FSE transmission interval (configurable, see configuration word “FSE transmission interval”)
Complete overhead:	83 bytes (UDP, IP and Ethernet overhead + FSE overhead)
Application data:	0 to 201 bytes, dependent on the configuration (see chapter “Performance parameters of the COM-FSE”)

Due to the different application data, the calculation must be carried out separately for each transmission direction.

4 Configuration

Detailed information about the configuration of the Frauscher Advanced Counter FAdC R2 can be taken from the documentation D21001 “System documentation Frauscher Advanced Counter FAdC R2”, chapter “Configuration”.

The structure of a configuration file ([IDENTIFICATION], [CONFIG] and [PROTECTION] blocks) is described in the documentation D21001 “System documentation Frauscher Advanced Counter FAdC R2”, chapter “Structure of a configuration file for AEB and COM”.

In the entry “COMPONENT” of the [PROTECTION] block for the communication board COM-FSE101, “108” must be entered as the identification of component.

4.1 Configuration of the communication board COM-FSE

Detailed information about the configuration of a communication board COM can be taken from the documentation D21001 “System documentation Frauscher Advanced Counter FAdC R2”, chapter “Configuration”.

For the configuration of the COM-FSE, the configuration words of the COM-AdC (see documentation D21001 “System documentation Frauscher Advanced Counter FAdC R2”, chapter “Configuration words of the COM”) as well as the specific configuration words of the COM-FSE (see chapter “Specific configuration words of the COM-FSE”) must be used.

Additionally, the DIP-switches must be set on the COM circuit board (see documentation D21001 “System documentation Frauscher Advanced Counter FAdC R2”, chapters “Setting of the DIP-switches” and “DIP-switches of the COM”).

For the communication between FAdC and safety system, it is subject of the specific application to demonstrate that the FSE protocol is suitable for the use in this safety-critical application, according to EN 50159.

4.1.1 Specific configuration words of the COM-FSE

4.1.1.1 Application data FAdC

This configuration word is used to configure, which application data regarding counting head, I/O information and track section (FMA) are transmitted to the safety system.

This configuration word

- is **optional**,
- can be configured **up to 40 times per COM-FSE**, if the connection to the safety system is used,
- may be configured only 1 time for each sender ID (see entry “CAN_TX_ID”),
- consists of **15 entries** with a total of **5 bytes**.

- The value of the individual time-outs 0 to 7 in the entry “SLCT_TIMEOUT” is configured in the configuration word “Time-out FAdC” (see entry “TIMEOUT_VALUE”).
- Data of a maximum of 40 AEB boards can be transmitted. The AEB boards can be on the local CAN bus or can be received via Ethernet. Further information about data transmission can be taken from the chapter “Performance parameters of the COM-FSE”.

Indicator	Bits	No. of bits	:	Value binary	Value decimal	Description
CFG_APPDATA_FADC	b39 ... b32	**8**	:	**0b01000000**	**64**	configuration application data FAdC
ZP	b31	**1**	:	**0b0** **0b1**	**0** **1**	information on direction (counting head information): does not transmit information on direction does transmit information on direction
SPEED	b30	**1**	:	**0b0** **0b1**	**0** **1**	information on speed: does not transmit information on speed does transmit information on speed

Indicator	Bits	No. of bits	:	Value binary	Value decimal	Description
WHEEL_DIAMETER	b29	**1**	:			information on wheel diameter:
				0b0	**0**	does not transmit information on wheel diameter
				0b1	**1**	does transmit information on wheel diameter
IO_DATA	b28	**1**	:			I/O information (24 data bits):
				0b0	**0**	does not transmit I/O information of the AEB to safety system
				0b1	**1**	does transmit I/O information of the AEB to safety system
RESERVED	b27 ... b24	**4**	:	**0b**0000	**0**	reserved
FMA1	b23	**1**	:			information on status of track section 1 (FMA 1):
				0b0	**0**	does not transmit information on status of track section 1 (FMA 1)
				0b1	**1**	does transmit information on status of track section 1 (FMA 1)
FMA1_COUNT	b22	**1**	:			current number of axles in track section 1 (FMA 1):
				0b0	**0**	does not transmit current number of axles in track section 1 (FMA 1)
				0b1	**1**	does transmit current number of axles in track section 1 (FMA 1)
FMA1_TRAIN_LENGTH	b21	**1**	:			indication of train length for track section 1 (FMA 1):
				0b0	**0**	does not transmit indication of train length for track section 1 (FMA 1)
				0b1	**1**	does transmit indication of train length for track section 1 (FMA 1)

Indicator	Bits	No. of bits	:	Value binary	Value decimal	Description
FMA2	b20	**1**	:			information on status of track section 2 (FMA 2):
				0b0	**0**	does not transmit information on status of track section 2 (FMA 2)
				0b1	**1**	does transmit information on status of track section 2 (FMA 2)
FMA2_COUNT	b19	**1**	:			current number of axles in track section 2 (FMA 2):
				0b0	**0**	does not transmit current number of axles in track section 2 (FMA 2)
				0b1	**1**	does transmit current number of axles in track section 2 (FMA 2)
FMA2_TRAIN_LENGTH	b18	**1**	:			indication of train length for track section 2 (FMA 2):
				0b0	**0**	does not transmit indication of train length for track section 2 (FMA 2)
				0b1	**1**	does transmit indication of train length for track section 2 (FMA 2)
RESERVED	b17 ... b15	**3**	:	**0b**000	**0**	reserved

Indicator	Bits	No. of bits	:	Value binary	Value decimal	Description
SLCT_TIMEOUT	b14 ... b12	**3**	:			selection of time-out between COM and AEB, whose data should be transmitted to safety system (see configuration word “Time-out FAdC”):
				0b00**0**	**0**	time-out 0
				…	**…**	…
				0b111	**7**	time-out 7
CAN_TX_ID	b11 ... b0	**12**	:			sender ID of AEB, whose data should be transmitted:
				0b000000000001	**1**	1
				…	**…**	…
				0b111111111111	**4 095**	4 095

Table 4.1: Application data FAdC

4.1.1.2 Application data addition

This configuration word is used to configure the application data addition.

This configuration word
- is **optional**, (i.e. if this configuration word is not configured, then the specified **default values** apply),
- can be configured **1 time per COM-FSE**, if the connection to the safety system is used,
- consists of **5 entries** with a total of **2 bytes**.

Indicator	Bits	No. of bits	:	Value binary	Value decimal	Description
CFG_APPDATA_ADD	b15 ... b8	**8**	**:**	**0b01000001**	**65**	configuration application data addition
RESERVED	b7 ... b3	**5**	**:**	**0b**0000**0**	**0**	reserved
COMP_MOD_R1	b2	**1**	**:**	**0b0** **0b1**	**0** **1**	compatibility mode “application data FAdC R1”: off = transmission of the application data according to FAdC R2 (default) on = FAdC R1-compatible (only if the implementation of the safety system was carried out according to FAdC R1)
CHECK	b1	**1**	**:**	**0b0** **0b1**	**0** **1**	checkbyte: does not add checkbyte (default) does add checkbyte
DATA_TO_FADC	b0	**1**	**:**	**0b0** **0b1**	**0** **1**	I/O information (24 data bits): does not transmit I/O information of the safety system to the FAdC (default) does transmit I/O information of the safety system to the FAdC

Table 4.2: Application data addition

If the entry “COMP_MOD_R1” is configured with ‘0’ (off), then the bit positions according to FAdC R2 from the documentation D4014 “Application data Communication between Interlocking and Frauscher Advanced Counter Release 2” are valid for the application data (see configuration word “Application data FAdC”).

If the entry “COMP_MOD_R1” is configured with ‘1’ (on), then the bit positions according to FAdC R1 from the documentation D3852 “Specification Application Data Version 1 Frauscher Safe Ethernet (FSE)” are valid for the application data (see configuration word “Application data FAdC”).

In this case, the following restrictions must be observed:

- Only the bit positions and possibly the inversion are adapted to the system FAdC R1. Therefore, it is possible that the time response of the system FAdC R1 is not identical with the time response of the system FAdC R2. The bits OCC and LCO of the FAdC R1 behave like the inverted bits OCC and RR of the FAdC R2.
- Within the system FAdC R1, the following entries in the configuration word “Application data (I/O data, counting head, track sections (FMA))” were not defined: “SPEED”, “WHEEL_DIAMETER”, “FMA1_TRAIN_LENGTH” and “FMA2_TRAIN_LENGTH” (see configuration word of the system FAdC R2 “Application data FAdC”). In case these data were configured in the configuration word “Application data FAdC”, then they are transmitted according to system FAdC R2.
- Within the system FAdC R1, the configuration word of the system FAdC R2 “Application data addition” with the following entries were not defined: “CHECK” and “DATA_TO_FADC”. In case these data were configured in the configuration word “Application data addition”, then they are transmitted according to system FAdC R2.

4.1.1.3 Timing FAdC

This configuration word is used to configure the minimum occupancy time, the direction pulse extension and the occupied status extension.

This configuration word

- is **mandatory** if in the configuration word “Application data FAdC” at least one of the entries “ZP” (information on direction), “FMA 1” or “FMA 2” (information on status of track section (FMA)) is used,
- must be configured **1 time per COM-FSE**,
- consists of **4 entries** with a total of **4 bytes**.

- The values used in this configuration word must be configured as big, that in case of a communication error either the failsafe status arrives at the safety system or that the safety system sets the failsafe status for the transmitted data autonomously.
- The minimum occupancy time (“TIME_MIN_OCC_FMA”) is the time, to which the occupied indications or fault indications are extended.
- The direction pulse extension (“TIME_DIR_IMP”) is the time, by which the direction pulses are extended.
- The occupied status extension (“TIME_OCC_EXT”) is the time by which the occupied indications or the fault indications are extended.

If the maximum distance between axles and the minimum traversing speed are known, then the direction pulse extension (“TIME_DIR_IMP”) can be configured in such a way, that only one direction pulse is output per train.

Indicator	Bits	No. of bits	:	Value binary	Value decimal	Description
CFG_TIMING	b31 ... b24	**8**	**:**	**0b01000010**	**66**	configuration timing FAdC
TIME_MIN_OCC_FMA	b23 ... b16	**8**	**:**			minimum occupancy time, to be configured in steps of 100 ms (from 0 to 25 500 ms) (≥ configured time-out between COM and safety system):
				0b00000000	**0**	0 ms
				0b00000001	**1**	100 ms
				...	**...**	…
				0b11111111	**255**	25 500 ms = 25,5 s
TIME_DIR_IMP	b15 ... b8	**8**	**:**			direction pulse extension, to be configured in steps of 100 ms (from 0 to 25 500 ms) (≥ configured time-out between COM and safety system):
				0b00000000	**0**	0 ms
				0b00000001	**1**	100 ms
				...	**...**	…
				0b11111111	**255**	25 500 ms = 25,5 s
TIME_OCC_EXT	b7 ... b0	**8**	**:**			occupied status extension, to be configured in steps of 100 ms (from 0 to 25 500 ms) (≥ configured time-out between COM and safety system):
				0b00000000	**0**	0 ms
				0b00000001	**1**	100 ms
				...	**...**	…
				0b11111111	**255**	25 500 ms = 25,5 s

Table 4.3: Timing FAdC

SAB FAdC-FSE100_13:
The configuration word „Timing FAdC“ must be configured mandatorily 1 time if at least one of the entries “ZP”, “FMA1” or “FMA2” from the configuration word “Application data FAdC” was configured at least 1 time for transmission.

SAB FAdC-FSE100_4:
The configured time for the minimum occupancy time (configuration word “Timing FAdC”, entry “TIME_MIN_OCC_FMA”) or the occupied status extension (configuration word “Timing FAdC”, entry “TIME_OCC_EXT”) must be greater than the FSE time-out of the safety system (time-out = time, until the safety system changes into the failsafe status after a communication interruption of the FSE connection to the COM-FSE101).

SAB FAdC-FSE100_8:

The configured time for the direction pulse extension (configuration word “Timing FAdC”, entry “TIME_DIR_IMP”) must be greater than the FSE time-out of the safety system (time-out = time, until the safety system changes into the failsafe status after a communication interruption of the FSE connection to the COM-FSE101).

4.1.1.4 Time-out FAdC

With this configuration word up to 8 various time-outs between AEB and COM-FSE can be configured, dependent on the requirement. Every time-out (time-out 0 to time-out 7) has a unique value for identification (see entry “SLCT_TIMEOUT”).
The value of the time-out depends on the configured transmission interval, the network delay and whether the communication takes place within a CAN segment or via COM boards.

This configuration word
- is **mandatory** if the configuration word “Application data FAdC” is used,
- must be configured **at least 1 time per COM-FSE**,
- can be configured **up to 8 times per COM-FSE**,
- consists of **4 entries** with a total of **3 bytes**.

- Each individual time-out 0 to 7 of the entry “SLCT_TIMEOUT” may be configured only 1 time.
- Each time-out, used in the entry “SLCT_TIMEOUT” of the configuration word “Application data FAdC”, must be configured in this configuration word.

Indicator	Bits	No. of bits	:	Value binary	Value decimal	Description
CFG_TIMEOUT	b23 ... b16	**8**	**:**	**0b**01**000011**	**67**	configuration time-out FAdC
RESERVED	b15 ... b11	**5**	**:**	**0b**0000**0**	**0**	reserved
SLCT_TIMEOUT	b10 ... b8	**3**	**:**	**0b**000 **…** **0b111**	**0** **…** **7**	configuration time-out FAdC: time-out 0 … time-out 7
TIMEOUT_VALUE	b7 ... b0	**8**	**:**	**0b**00000000 **0b**00000001 **0b**00000010 **…** **0b11111111**	**0** **1** **2** **…** **255**	value of the time-out, to be configured in steps of 10 ms (from 20 to 2 550 ms): not allowed not allowed 20 ms … 2 550 ms = 2,55 s

Table 4.4: Time-out FAdC

4.1.1.5 IP address of the safety system

This configuration word is used to configure the IP address of the safety system for network 1 and network 2. Optionally only one of the both networks can be used.

This configuration word
- is **mandatory**, if the connection to the safety system is used,
- must be configured at least **1 time**,
- can be configured **1 time per network for multicast**,
- can be configured **up to 2 times per network for unicast**,
- consists of **5 entries** with a total of **5 bytes**.

- The IP address range from 224.0.0.0 to 239.255.255.255 is reserved for multicast. IP addresses from 224.0.0.0 to 224.0.0.255 must not be used.
- Via the configuration of an IP address from the multicast IP address range, the transmission mode for multicast is activated.

Indicator	Bits	No. of bits	:	Value binary	Value decimal	Description
CFG_IXL_IP_ADDR	b39 … b32	**8**	:	**0b01000110** **0b01000111**	**70** **71**	configuration IP address of the safety system: network 1 network 2
IXL_IP_ADDR_BYTE1	b31 ... b24	**8**	:			IP address of the safety system, byte 1
IXL_IP_ADDR_BYTE2	b23 ... b16	**8**	:			IP address of the safety system, byte 2
IXL_IP_ADDR_BYTE3	b15 ... b8	**8**	:			IP address of the safety system, byte 3
IXL_IP_ADDR_BYTE4	b7 ... b0	**8**	:			IP address of the safety system, byte 4

Table 4.5: IP address of the safety system

4.1.1.6 Own UDP port and UDP port Destination

This configuration word is used to configure the own UDP port and the UDP port Destination for the communication with the safety system.

This configuration word
- is **optional** (i.e. if this configuration word is not configured, then the specified **default values** apply),
- can be configured **1 time per COM-FSE** if the connection to the safety system is used,
- consists of **3 entries** with a total of **5 bytes**.

- For network 1 and for network 2, always the same own UDP port is used.
- For network 1 and for network 2, always the same UDP port Destination is used.

Indicator	Bits	No. of bits	:	Value binary	Value decimal	Description
CFG_UDP_PORT	b39 ... b32	**8**	**:**	**0b**01**000101**	**69**	configuration own UDP port and UDP port Destination
UDP_PORT	b31 ... b16	**16**	**:**			own UDP port (from 1 to 65 534):
				0b0000000000000000	**0**	not allowed
				0b0000000000000001	**1**	1
				…	**…**	…
				0b0001**110101001100**	**7 500**	7 500 (default)
				…	**…**	…
				0b1111111111111110	**65 534**	65 534
				0b1111111111111111	**65 535**	not allowed
UDP_PORT_IXL	b15 ... b0	**16**	**:**			UDP port Destination (from 1 to 65 535):
				0b0000000000000000	**0**	not allowed
				0b0000000000000001	**1**	1
				…	**…**	…
				0b0001**110101001100**	**7 500**	7 500 (default)
				…	**…**	…
				0b1111111111111111	**65 535**	65 535

Table 4.6: Own UDP port and UDP port Destination for the communication with the safety system

4.1.1.7 FSE Source Address

This configuration word is used to configure the FSE Source Address for the communication with the safety system. The FSE Source Address, from which the data are sent, corresponds to the FSE Destination Address of the safety system.

This configuration word
- is **mandatory** if the connection to the safety system is used,
- must be configured **1 time per COM-FSE**,
- consists of **2 entries** with a total of **5 bytes**.

- Each COM-FSE can establish 1 logical connection to a safety system. Even in case of a redundantly designed safety system, the Source Address may be assigned only 1 time.

Indicator	Bits	No. of bits	:	Value binary	Value decimal	Description
CFG_FSE_SA	b39 ... b32	**8**	**:**	**0b01001001**	**73**	configuration FSE Source Address
SA	b31 ... b0	**32**	**:**		**0** **...** **4 294 967 295**	FSE Source Address (from 0 to 4 294 967 295): 0 … 4 294 967 295

Table 4.7: FSE Source Address

SAB FAdC-FSE100_12:
During configuration it must be observed, that the FSE Source Address of the COM-FSE101 may only be used 1 time within a physical network.

Regarding SAB FAdC-FSE100_12:
This means that also other network participants with FSE protocol must not use this address as FSE-Source Address.

4.1.1.8 FSE Destination Address

This configuration word is used to configure the Destination Address for the communication with the safety system. The FSE Destination Address corresponds to the FSE Source Address of the safety system, to which the data are sent.

This configuration word
- is **mandatory** if the connection to the safety system is used,
- must be configured **1 time per COM-FSE**,
- consists of **2 entries** with a total of **5 bytes**.

Indicator	Bits	No. of bits	:	Value binary	Value decimal	Description
CFG_FSE_DA	b39 ... b32	**8**	**:**	**0b01001000**	**72**	configuration FSE Destination Address
DA	b31 ... b0	**32**	**:**		**0** **...** **4 294 967 295**	FSE Destination Address (from 0 to 4 294 967 295): 0 … 4 294 967 295

Table 4.8: FSE Destination Address

4.1.1.9 FSE Source Port and FSE Destination Port

This configuration word is used to configure the FSE Source Port (corresponds to the Destination Port of the safety system) and the Destination Port (corresponds to the FSE Source Port of the safety system) for the communication with the safety system.

This configuration word
- is **mandatory** if the connection to the safety system is used,
- must be configured **1 time per COM-FSE**,
- consists of **3 entries** with a total of **3 bytes**.

Indicator	Bits	No. of bits	:	Value binary	Value decimal	Description
CFG_FSE_DP_SP	b23 ... b16	**8**	**:**	**0b01001010**	**74**	configuration FSE Source Port and FSE Destination Port
FSE_SP	b15 ... b8	**8**	**:**	**0b**00000000 **…** **0b11111111**	**0** **…** **255**	FSE Source Port (from 0 to 255): 0 … 255
FSE_DP	b7 ... b0	**8**	**:**	**0b**00000000 **…** **0b11111111**	**0** **…** **255**	FSE Destination Port (from 0 to 255): 0 … 255

Table 4.9: FSE Source Port and FSE Destination Port

4.1.1.10 FSE transmission interval

This configuration word is used to configure the FSE transmission interval for the communication with the safety system.

This configuration word

- is **optional** (i.e. if this configuration word is not configured, then the specified **default value** applies),
- can be configured **1 time per COM-FSE** if the connection to the safety system is used,
- consists of **2 entries** with a total of **3 bytes**.

Indicator	Bits	No. of bits	:	Value binary	Value decimal	Description
CFG_FSE_INTERVAL	b23 ... b16	**8**	**:**	**0b**01**001011**	**75**	configuration FSE transmission interval
FSE_INTERVAL	b15 ... b0	**16**	**:**			transmission interval, to be configured in steps of 10 ms (from 100 to 10 000 ms):
				0b0000000000000000	**0**	not allowed
				…	**…**	not allowed
				0b0000000000001**001**	**9**	not allowed
				0b0000000000001**010**	**10**	100 ms (default)
				…	**…**	…
				0b0000001**111011110**	**990**	9 990 ms = 9,99 s
				0b0000001**111101000**	**1 000**	10 000 ms = 10 s

Table 4.10: FSE transmission interval

4.1.1.11 FSE time-out

This configuration word is used to configure the time-out for the communication with the safety system.

This configuration word
- is **optional** (i.e. if this configuration word is not configured, then the specified **default value** applies),
- can be configured **1 time per COM-FSE** if the connection to the safety system is used,
- consists of **2 entries** with a total of **3 bytes**.

Indicator	Bits	No. of bits	:	Value binary	Value decimal	Description
CFG_FSE_TIMEOUT	b23 ... b16	**8**	**:**	**0b01001100**	**76**	configuration FSE time-out
FSE_TIMEOUT	b15 ... b0	**16**	**:**			time-out, to be configured in steps of 10 ms (from 0 to 60 000 ms):
				0b0000000000000000	**0**	0 ms
				…	**…**	…
				0b0000000001010000	**40**	400 ms = 0,4 s (default)
				…	**…**	…
				0b0001011101110000	**6 000**	60 000 ms = 60 s

Table 4.11: FSE time-out

5 Troubleshooting on the COM-FSE

The troubleshooting on the communication board COM-FSE can be carried out via the LED indications on the front panel of the COM-FSE (see D21001 “System documentation Frauscher Advanced Counter FAdC R2”, chapter “LED indications on the COM”) and via the Advanced Service Display ASD or the Frauscher Diagnostic System FDS.

5.1 Error codes of the COM-FSE

In addition to the general error codes of the communication board COM-AdC that are described in the documentation D21001 “System documentation Frauscher Advanced Counter FAdC R2” in the chapter “Error codes of the COM”, the COM-FSE outputs specific error codes and error codes regarding the safety system.

It is recommended to note the error codes in case errors occur in order to improve the traceability of occurred errors and/or faults.

5.1.1 Board error codes of the COM-FSE

The COM-FSE outputs error codes in case of an error or an invalid configuration, which can be taken from the following table. The error codes can be read out with the diagnostic tools ASD and FDS. In case an error code regarding configuration occurs, the configuration must be amended by the project engineer. The error that appears at first is indicated. If subsequent errors occur, then further measures might be necessary. In case an internal error occurs, it must be preceded according to the possible measures. An error code of the COM-FSE consists of a category given by Frauscher (number in front of the slash) and an error code within a category (number behind the slash).

Error code	Meaning	Possible measure(s)
Category 8: Error in the FSE configuration contents (configuration words)		
8 / 17	invalid FSE transmission interval	amend configuration in the configuration word “FSE transmission interval”
8 / 38	too many bytes in the application data at transmission from COM-FSE to the safety system	amend configuration in the configuration word “Application data FAdC”
8 / 41	the UDP port 65 535 is used as own UDP port	amend configuration in the configuration word “Own UDP port and UDP port Destination”
Category 50: Error in the FSE configuration contents (configuration words)		
50 / 1	configuration word “Own IP address master COM for network 1” configured more than 1 time or not configured (see D21001 “System documentation Frauscher Advanced Counter FAdC R2”)	amend configuration in the configuration word “Own IP address master COM for network 1”
50 / 2	configuration word “Own IP address master COM for network 2” configured more than 1 time or not configured (see D21001 “System documentation Frauscher Advanced Counter FAdC R2”)	amend configuration in the configuration word “Own IP address master COM for network 2”
50 / 3	configuration word “IP switching” configured more than 1 time (see D21001 “System documentation Frauscher Advanced Counter FAdC R2”)	amend configuration in the configuration word “IP switching”

Error code	Meaning	Possible measure(s)
50 / 4	configuration word “Input filter for diagnostic data” configured more than 1 time (see D21001 “System documentation Frauscher Advanced Counter FAdC R2”)	amend configuration in the configuration word “Input filter for diagnostic data”
50 / 5	configuration word “Own UDP port and UDP port Destination” configured more than 1 time	amend configuration in the configuration word “Own UDP port and UDP port Destination”
50 / 6	network 1 in the configuration word “IP address of the safety system” configured more than 2 times or not configured	amend configuration in the configuration word “IP address of the safety system”
50 / 7	network 2 in the configuration word “IP address of the safety system” configured more than 2 times or not configured	amend configuration in the configuration word “IP address of the safety system”
50 / 8	configuration word “FSE Destination address” configured more than 1 time or not configured	amend configuration in the configuration word “FSE Destination address”
50 / 9	configuration word “FSE Source Address” configured more than 1 time or not configured or FSE Source Address is identical with the FSE Destination address	amend configuration in the configuration word “FSE Source Address”
50 / 10	configuration word “FSE Source Port and FSE Destination Port” configured more than 1 time or not configured	amend configuration in the configuration word “FSE Source Port and FSE Destination Port”
50 / 11	configuration word “FSE time-out” configured more than 1 time or the value for the FSE time-out is > 60 000 ms	amend configuration in the configuration word “FSE time-out”
50 / 12	FSE configuration not complete	amend configuration
50 / 13	the UDP port 65 535 is used as own UDP port	amend configuration in the configuration word “Own UDP port and UDP port Destination”
50 / 14	the own UDP port and/or the UDP port Destination are configured with ‘0’	amend configuration in the configuration word “Own UDP port and UDP port Destination”
50 / 15	in case of redundant operation: no IP address master COM for network 1 configured	configure the IP address master COM for network 1 in the configuration word “Own IP address master COM for network 1” (see D21001 “System documentation Frauscher Advanced Counter FAdC R2”)

Error code	Meaning	Possible measure(s)
50 / 16	in case of redundant operation: no IP address master COM for network 2 configured	configure the IP address master COM for network 2 in the configuration word “Own IP address master COM for network 2” (see D21001 “System documentation Frauscher Advanced Counter FAdC R2”)
Category 51: Error FSE		
51 / 1 to 51 / 15	internal errors	note the error code; interrupt power supply by unplugging and plugging in the COM-FSE; in case the error persists consult Frauscher and if necessary send the board back to Frauscher; replace the defective COM-FSE if another COM-FSE of the same type is available

Table 5.1: Board error codes of the COM-FSE

5.1.2 Diagnostic error codes of the COM-FSE regarding the connection to the safety system

In case of restricted availability of the connection to the safety system, the COM-FSE outputs error codes, which can be taken from the following table. The error codes can be read out with the diagnostic tools ASD and FDS.

Error code	Meaning	Possible measure(s)
1	received data packet is too small (less than 29 bytes of data)	check protocol implementation of the safety system, check sender of data packet
2	received data packet is too big (more than 541 bytes of user data)	check protocol implementation of the safety system, check sender of data packet
3	verification of CRC32 failed	check protocol implementation of the safety system, check sender of data packet
4	verification of inverted CRC32 failed	check protocol implementation of the safety system, check sender of data packet
5	protocol version is unequal 2	check protocol implementation of the safety system, check sender of data packet
6	verification of TX timestamp failed	check configuration in the configuration word “FSE time-out”, check network
7	verification of RX timestamp failed	check configuration in the configuration word “FSE time-out”, check network
8	no valid data packets received within the FSE time-out	check configuration in the configuration word “FSE time-out”, check network
9	internal error	note the error code; interrupt power supply by unplugging and plugging in the COM-FSE; in case the error persists consult Frauscher and if necessary send the board back to Frauscher; replace the defective COM-FSE if another COM-FSE of the same type is available
10	Destination Address does not correspond with the configured Destination Address	amend configuration in the configuration word “FSE Destination Address” or in the safety system; check IP settings of the boards which are not part of the communication
11	Source Address does not correspond with the configured Source Address	amend configuration in the configuration word “FSE Source Address” or in the safety system; check IP settings of the boards which are not part of the communication

Error code	Meaning	Possible measure(s)
12	Destination Port does not correspond with the configured Destination Port	amend configuration in the configuration word “FSE Source Port and FSE Destination Port” or in the safety system; check IP settings of the boards which are not part of the communication
13	Source Port does not correspond with the configured Source Port	amend configuration in the configuration word “FSE Source Port and FSE Destination Port” or in the safety system; check IP settings of the boards which are not part of the communication
14	internal error	note the error code; interrupt power supply by unplugging and plugging in the COM-FSE; in case the error persists consult Frauscher and if necessary send the board back to Frauscher; replace the defective COM-FSE if another COM-FSE of the same type is available
15	internal error	note the error code; interrupt power supply by unplugging and plugging in the COM-FSE; in case the error persists consult Frauscher and if necessary send the board back to Frauscher; replace the defective COM-FSE if another COM-FSE of the same type is available
60	too many or not enough application data received	amend configuration in the configuration word “Application data FAdC”

Table 5.2: Diagnostic error codes of the COM-FSE regarding connection to the safety system