



BSI Standards Publication

Communication systems for meters

Part 4: Wireless M-Bus communication

National foreword

This British Standard is the UK implementation of EN 13757-4:2025. It supersedes BS EN 13757-4:2019, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PEL/894, Remote Meter Reading.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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: Communication sans fil M-Bus

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M-Bus-Kommunikation

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European foreword

This document (EN 13757-4:2025) has been prepared by Technical Committee CEN/TC 294 “Communication systems for meters”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2026, and conflicting national standards shall be withdrawn at the latest by June 2026.

This document supersedes EN 13757-4:2019.

EN 13757-4:2024 includes the following significant technical changes with respect to EN 13757-4:2019:

- Update of referenced standards to the most recent versions;
- Including of sensors and actuators used as a part of providing metering services;
- Removal of Lowest Transmitter Class L_T and Lowest Receiver Class L_R , see 5.3, 6.3, 7.3, 8.3, 9.3 and 10.3;
- Removal of Digital bit jitter, see 6.2, 7.2 and 8.2;
- Explanatory note on addressing, see 12.5.6;
- Extension of installation messages schemes, see 12.6.1;
- Introduction of FAC transmission delay, see 14.2.2, 14.3.3 and 14.4.2;
- Introduction of Error2 reporting, see 14.2.3 and 14.4.3;
- SF2 field is populated, see 14.3.3.3;
- Updated frequency allocation for the 868 MHz band, align format with Annex B see Annex A.

This document has been prepared under a standardization request addressed to CEN by the European Commission. The Standing Committee of the EFTA States subsequently approves these requests for its Member States.

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.

Introduction

This document belongs to the EN 13757 series, which covers communication systems for meters.

EN 13757-1 contains generic descriptions and a communication protocol.

EN 13757-2 contains a physical and a link layer for twisted pair based Meter-Bus (M-Bus).

EN 13757-3 describes the Application Layer protocols (often called M-Bus).

EN 13757-5 describes the wireless network used for repeating, relaying, and routing for the different modes of EN 13757-4.

EN 13757-7 describes transport and security services.

EN 13757-8 describes the Adaptation Layer to be applied for wireless communication other than wireless M-Bus

These upper M-Bus protocol layers can be used with various physical layers and with link layers and network layers, which support the transmission of variable length binary transparent messages. Frequently, the physical and link layers of EN 13757-2 (twisted pair) and EN 13757-4 (wireless) as well as EN 13757-5 (wireless with routing function) or the alternatives described in EN 13757-1 are used.

The different parts of this standard are complemented by CEN/TR 17167, which provides examples and supplementary information related to EN 13757-2, EN 13757-3 and EN 13757-7.

These upper M-Bus protocol layers have been optimized for minimum battery consumption of meters, especially for the case of wireless communication, to ensure long battery lifetimes of the meters. Secondly, it is optimized for minimum message length to minimize the radio channel occupancy and hence the collision rate. Thirdly, it is optimized for minimum requirements towards the meter processor regarding requirements of RAM size, code length and computational power.

This document concentrates on the meter communication. The meter communicates with one (or occasionally several) fixed or mobile communication partners which again might be part of a private or public network. These further communication systems might use the same or other Application Layer protocols, security, privacy, authentication, and management methods.

This document is not affected by any of the requirements in Directive 2004/22/EC as it only covers the basic transmission of information from the meter to an external entity. This document ensures that data transmitted cannot be modified without it being detected. Confidentiality, integrity, and authenticity are provided by the capabilities specified in other parts of the EN 13757 series of standards. This document does not specify any of the metering capabilities of the meter nor the metrological capabilities of the meter.

This document enables encrypted transfer data either directly or as specified in other parts of the EN 13757 series of standards. The encryption ensures the confidentiality of any personal data.

This document provides capabilities of interoperability of meters as requested in M/441 which can be used to improve the customer awareness of actual consumption.

European Committee for Standardization (CEN) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent concerning forward error correction (FEC) given in 12.8.

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1 Scope

This document specifies the requirements of parameters for the physical and the link layer for systems using radio to remotely read meters. The primary focus is to use the Short Range Device (SRD) unlicensed bands. This document encompasses systems for walk-by, drive-by and fixed installations. As a broad definition, this document can be applied to various Application Layers.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 13757-1, *Communication systems for meters - Part 1: Data exchange*

EN 13757-3:2025, *Communication systems for meters - Part 3: Application protocols*

EN 13757-7:2025, *Communication systems for meters - Part 7: Transport and security services*

EN 60870-5-1, *Telecontrol equipment and systems - Part 5: Transmission protocols - Section 1: Transmission frame formats*(IEC 60870-5-1)

EN 60870-5-2, *Telecontrol equipment and systems - Part 5: Transmission protocols - Section 2: Link transmission procedures*(IEC 60870-5-2)

ETSI EN 300 220-1, V3.1.1:2017-02, *Short Range Devices (SRD) operating in the frequency range 25 MHz to 1 000 MHz — Part 1: Technical characteristics and methods of measurement*

ETSI EN 300 220-2, *Short Range Devices (SRD) operating in the frequency range 25 MHz to 1 000 MHz — Part 2: Harmonised Standard for access to radio spectrum for non specific radio equipment*

ETSI EN 300 220-4, *Short Range Devices (SRD) operating in the frequency range 25 MHz to 1 000 MHz — Part 4: Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU; Metering devices operating in designated band 169,400 MHz to 169,475 MHz*

CCSDS 131.0-B-5, *TM Synchronization and Channel Coding*, Consultative Committee for Space Data Systems (CCSDS), Issue-5, September 2023

ERC/REC 70-03, Relating to the use of Short Range Devices (SRD), issued by the European Conference of Postal and Telecommunications Administrations (CEPT), Electronics Communications Committee on 2024-06

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp/>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

BER

bit error rate

3.2

FEC

forward error correction

3.3

frame

unit of transmission at the Data Link Layer

3.4

FSK

frequency shift keying

3.5

Gateway

Other Device with data connection outside the metering network

3.6

GFSK

gaussian frequency shift keying

3.7

individual transmission interval

exact time between two subsequent synchronous or periodical transmissions which changes with each transmission

3.8

LSB

least significant byte

3.9

LSBit

least significant bit

3.10

message

set of data at the Application Layer

3.11

meter

measuring device for water or energy consumption,

Note 1 to entry: This part of the standard defines only the lower communication layers of the metering system. Here the term meter also includes sensors and actuators used to provide metering services.

3.12

MSB

most significant byte

3.13

MSBit

most significant bit

3.14**nominal transmission interval**

average transmission interval between all synchronous or periodical messages (new, old or no data content) for wireless meters

3.15**NRZ**

non-return-to-zero

3.16**Other Device**

device exchanging information with a meter

Note 1 to entry: A repeater is not an Other Device, as it is not exchanging information but just passing it on. A communications controller (Gateway) is an Other Device. A physical meter may take this role if supporting additional network functions.

3.17**PER**

packet error rate

3.18**RSSI**

received signal strength indicator

4 Symbols and abbreviated terms**4.1 Symbols**

Hexadecimal notation is designated by a following "h".

Binary numbers are designated by a following "b".

Decimal numbers have no suffix.

4.2 Abbreviated terms

For the purposes of this document, the following abbreviated terms apply.

CI	control information
Ident no.	Identification number (serial number) (part of meter address)
Manuf.	Manufacturer acronym (part of meter address)
Ver.	Version (part of meter address)
ACC	access number (refer to EN 13757-7)
STS	status (refer to EN 13757-7)
Conf. Field	configuration field (refer to EN 13757-7)
M-2-O	meter to Other Device (transmission direction)
O-2-M	Other Device to meter (transmission direction)
min.	minimum value
nom.	nominal value

max.	maximum value
RFU	reserved for future use
MBAL	M-Bus adaptation layer (refer to EN 13757-8)
FAC	Frequent Access Cycle

5 General

5.1 Modes of operation

The “meters” may communicate with “other” system components, for example mobile readout devices, stationary receivers, data collectors, multi-utility concentrators or system network components. Such devices are in this document named “Other Device”. For the meter side, it is assumed that the communication function will work without any operator’s intervention or need for battery replacement over the full lifetime of the radio part of the meter. Other components such as the mobile readout or stationary equipment may have a shorter battery lifetime or require an external power supply as dictated by the technical parameters and use.

Several different modes of operation are defined for the communication with the meter. Many of the physical and link layer parameters of these different modes are identical, allowing the use of common hardware and software. However, due to the operational and technical requirements of these modes some parameters will differ.

The name of a mode is specified by a letter and a number. The letter specifies a mode and the number specifies whether the modes supports unidirectional (= 1) or bidirectional (= 2) data transfer.

- a) “Stationary mode”, mode S is intended for unidirectional or bidirectional communications between the meter and a stationary or mobile device. A special transmit only sub-mode S1 is optimized for stationary battery operated devices with a long header and the sub-mode S1-m is specialized for mobile receivers.
- b) “Frequent transmit mode”, mode T. In this mode, the meter transmits a very short frame (typically 3 ms to 8 ms) every few seconds, thus allowing walk-by and/or drive-by readout.

Transmit only sub-mode T1. It is the minimal transmission of a meter ID plus a readout value, which is sent periodically.

The bidirectional sub-mode T2 transmits frequently a short frame containing at least its ID and then waits for a very short period after each transmission for the reception of a response. The reception of a response will open a bidirectional communication channel. Alternatively, the initial frame contains the readout value as well, and the downlink response is only used for special services.

- c) “Frequent receive mode”, mode R. In this mode only R2 is relevant, as R1 makes no sense. The meter listens every few seconds for the reception of a wakeup message from a mobile transceiver. After receiving such a wakeup, the device will prepare for a few seconds of communication dialogue with the initiating transceiver. In this mode a “multi-channel receive mode” allows the simultaneous readout of several meters, each one operating on a different frequency channel. This mode is as well applicable to stationary Other Devices.
- d) “Compact Mode” mode C. This mode is similar to mode T but it allows for transmission of more data within the same energy budget and with the same duty cycle. It supports the sub-modes C1 and C2 for unidirectional and bidirectional devices. It is suitable for walk-by and/or drive-by readout. The shared reception of mode T and mode C frames with a single receiver is possible.

- e) “Narrowband VHF”, mode N. Optimized for narrowband operation in the 169 MHz frequency band, allocated for meter reading and a few other services. The radio range of sub-modes can be extended using repeaters. Sub-band A is intended for, but not limited to, long range secondary communication using multi-hop repeaters.
- f) “Frequent receive and transmit mode”, mode F. Used in the 433 MHz frequency band for long range communications. In the bidirectional sub-modes F2-m, the meter listens every few seconds for the reception of a wake up message from a stationary or mobile transceiver. After receiving such a wake up message, the device prepares for a few seconds of communication dialogue with the initiating transceiver. The bidirectional sub-mode F2 transmits a frame and waits for a short period for the reception of a response. The response will open for bidirectional communication.

Meters or other communication devices may support one, multiple or all of the described modes.

NOTE Additional modes, supporting repeating and routing of data, are specified in EN 13757-5.

5.2 Meter communication types

Table 1 describes the key features of each mode and sub-mode.

Table 1 — Meter communication types

Modes and sub-modes	WAY	Typical use	Chip-rate (in kcps)	Maximum duty cycle ^a	Data coding and header	Description
S1	1	Transmit only meter for stationary receiving readout	32,768	0,02 % ^b	Manchester and long header	Transmit only; transmits a number of times per day to a stationary receiving point. Transmits in the 1 % duty cycle frequency band. Due to long header, it is suitable also for battery economized receiver.
S1-m	1	Transmit only meter for mobile or stationary readout	32,768	0,02 % ^b	Manchester and short header	Transmit only; transmits with a duty cycle limitation of 0,02 % per hour to a mobile or stationary receiving point. Transmits in a 1 % duty cycle frequency band. Requires a continuously enabled receiver.
S2	2	All meter types. Stationary readout	32,768	1 %	Manchester and short header or optionally long header	Meter with a receiver either continuously enabled or synchronized requiring no extended preamble for wakeup. Also usable for node transponders or concentrators. A long header is optional.
T1	1	Frequent transmission	100	0,1 %	3 out of 6 and short header	Transmit only, transmits with short data, operates in a 0,1 % duty cycle frequency band.

Modes and sub-modes	WAY	Typical use	Chip-rate (in kcps)	Maximum duty cycle ^a	Data coding and header	Description
T2	2	Frequent transmission	M-2-O: 100	0,1 %	3 out of 6 and short header	Meter transmits on a regular basis like Type T1 and its receiver is enabled for a short period after the end of each transmission and locks on, if an T2 preamble with Synchronisation word (O-2-M) is received. Further bidirectional communication may follow.
		(meter with two way capability)	O-2-M: 32,768		Manchester and short header	
R2	2	Frequent reception (long range)	4,8	1 %	Manchester and medium header	Meter receiver with possible battery economizer, requiring extended preamble for wake-up. Optionally, it may have up to 10 frequency channels with a high precision frequency division multiplexing. Meter responds with 4,8 kcps wake-up followed by a 4,8 kcps header.
C1	1	Frequent transmit only meter for mobile or stationary readout	100	0,1 %	NRZ and short header	Transmit only, on a regular basis, with short data bursts, operates in a 0,1 % duty cycle frequency band.
C2	2	Frequent transmit meter for mobile or stationary readout	M-2-O: 100	M-2-O: 0,1 %	NRZ, short header	Meter transmits on a regular basis like Type C1 and its receiver is enabled for a short period after the end of each transmission and locks on if a proper preamble and synchronization word is detected. Data frames received by the meter are used for protocol updates and commands.
			O-2-M: 50	O-2-M: 10 %		
N1	1	Long range transmission for stationary readout.	2,4, 4,8, 6,4 or 19,2	10 % or less ^c	NRZ	Transmit only, transmits on a regular basis to a stationary receiving point.
N2	2	Long range two-way communication for stationary readout.	2,4, 4,8, 6,4 or 19,2	10 % or less ^c	NRZ	Meter transmits on a regular basis like mode N1 and its receiver is enabled for a short period after the end of each transmission. It locks on if a proper preamble and synchronization word is detected.
F2-m	2	Long range two-way communication	2,4	10 %	NRZ	Meter receiver with possible battery economizer, requiring extended preamble for wake-up.

Modes and sub-modes	WAY	Typical use	Chip-rate (in kcps)	Maximum duty cycle ^a	Data coding and header	Description
F2	2	Long range two-way communication for stationary readout.	2,4	10 %	NRZ	Meter unit transmits on a regular basis. Its receiver is enabled for a short period after the end of each transmission. It locks on if a proper preamble and synchronization word is detected.
All						A system component may operate simultaneously, sequentially or by command in more than one mode as long as it fulfils all the requirements of each of these modes.
^a The duty cycle limitation shall conform to the frequency band allocation defined for operation in the applicable frequency bands according to ERC/REC 70-03. ^b The total occupancy of the channel shall be limited to < 10 %. This implies that the duty cycle per meter shall be limited to 0,02 % per hour with 500 metering devices installed within transmission range. ^c The duty-cycle is sub-band dependent. Limits are according to EU Commission Decision 2022/180/EU.						

5.3 Performance classes

The transmitters shall belong to one of two Classes ranging from medium to highest radiated power (see Table 2).

The maximum allowable radiated power for the transmitter is defined according to ERC/REC 70-03.

NOTE Attention is drawn to local radio regulations that can apply.

The transmission power shall be measured as the effective radiated power (ERP) according to ETSI EN 300 220-1, V3.1.1:2017, 5.2.

An overview of the frequency ranges and power levels allocated in the 860 MHz band is found in Annex A

When existing, the receiver shall belong to one of two Classes in sensitivity and blocking performance; from medium to highest (see Table 3). The performance Class of receivers and transmitters defines power, sensitivity, and selectivity. The performance Class of the transmitter and the receiver may be different.

The maximum usable sensitivity shall be measured according to ETSI EN 300 220-1, V3.1.1:2017, 5.14.

Table 2 — Transmitter performance classes

Transmitter Class	Typical application	Description	Direction	Minimum ERP (P_{erp})
M_T	Medium performance	Medium transmission power	Both	0 dBm (all but mode N) +10 dBm (mode N)
H_T	Highest performance	Highest transmission power	M-2-0	+5 dBm (mode R, S, T, C) +3 dBm (mode F) +20 dBm (mode N, sub-band A)
			O-2-M	+8 dBm (mode R, S, T, C) +7 dBm (mode F) +20 dBm (mode N sub-band A)

Table 3 — Receiver performance classes

Receiver Class	Typical application	Description	Required sensitivity level P_0
M_R	Medium performance	Medium sensitivity, good blocking performances	–90 dBm (mode R,S,T,C) –100 dBm (mode N) –110 dBm (mode F)
H_R	Highest performance	Best sensitivity and best blocking performances	See Table 6, Table 9, Table 13, Table 16, Table 23 and Table 26

6 Mode S

6.1 Channel properties

The radio part of a meter shall, for all parameters, as a minimum conform to the requirements of ETSI EN 300 220-1 and ETSI EN 300 220-2 even if some application requires extended temperature or voltage range. The specific requirements for frequency band duty cycle are given in Table 4 below.

Table 4 — Mode S, Channel properties

Characteristic	min.	max.	Unit
Frequency band ^a	868,0	868,6	MHz
Transmitter duty cycle S2 ^b		1	%
Transmitter duty cycle S1 and S1-m ^c		0,02	%
^a This document is optimized for the 868 MHz to 870 MHz band, although, with an appropriate transmission licence, other frequency bands could be used. ^b Duty cycle as defined by ETSI EN 300 220-1, V3.1.1:2017, 5.4. ^c The duty cycle is limited to 0,02 % per hour to limit the total occupancy of the channel, see Table 1, Footnote b.			

NOTE See Figure A.1 and Figure A.2 for additional information on frequency and power recommendations.

6.2 Transmitter

The parameters for the transmitter shall be as listed in Table 5 below:

Table 5 — Mode S, Transmitter

Characteristic	Mode	Symbol	min.	nom.	max.	Unit	Note
Centre frequency (transmit only Meter, S1-submode)			868,25	868,30	868,35	MHz	±60 ppm
Centre frequency (Other Device and S2-mode)			868,278	868,300	868,322	MHz	±25 ppm
FSK Deviation			±40	±50	±80	kHz	
Chip rate transmit		f_{chip}		32,768		kcps	
Chip rate tolerance					±1,5	%	
Data rate (Manchester) ^b				$f_{\text{chip}} \times 1/2$		bps	
Preamble length including bit/byte-sync, both directions	S2, S1-m		48			chips	
Preamble length including bit/byte-sync	S1	PL	576			chips	Optional for S2
Postamble (trailer) length ^c			2		8	chips	
Response delay ^{a d} (O-2-M communication)		t_{RO}	3		15	ms	
FAC Transmission delay ^{e f}	S2	t_{TXD}	$N \times 1\,000 - 0,5$	$N \times 1000$	$N \times 1\,000 + 0,5$	ms	$N = 2, 3, \text{or } 5$
FAC Time out ^g	S2	t_{TO}	25		30	s	

^a EN 13757-4:2013 applies a maximum response delay O-2-M of 50 ms.

^b Each bit shall be coded as 2 chips (Manchester encoding).

^c The postamble (trailer) shall consist of $n = 1$ to 4 “ones” i.e. the chip sequence is $n \times (01)$.

^d Response delay: The receiver shall be ready for the reception of a response in a time shorter than the minimum response delay and shall be receiving at least until the maximum response delay (referred to the end of previous transmission).

^e FAC Transmission delay: describes the duration which a meter shall delay the first response to a received message from the Other Device referred to its last transmission. This delay shall also be applied between the first response of the Meter and the next repeated response of the Meter and all following repeated responses during the FAC. The reference time point shall be the end of preamble (end of sync sequence) of the meter transmission. For timing diagrams see Annex E.

^f The selected timeslot N shall be the same throughout the Frequent Access Cycle.

^g FAC Time out: is the time period between the last successful reception of a frame from the Other Device during the FAC and the moment where the repetition of the last response of the Meter shall be stopped (end of FAC).

6.3 Receiver

The parameters for the receiver shall be as listed in Table 6 below.

Table 6 — Mode S, Receiver

Characteristic	Class	Symbol	min.	nom.	max.	Unit	Note
Sensitivity (BER < 10 ⁻²) or (PER < 0,8)	H_R	P_o	-100	-105		dBm	Frame size of 20 bytes
Blocking performance ^a	M_R		2			Category	
Blocking performance ^a	H_R		2			Category	
Acceptable chip rate variation		D_{fchip}			±2	%	
Chip rate (Meter)		f_{chip}		32,768		kcps	
^a Receiver blocking performance according to ETSI EN 300 220-1, V3.1.1:2017, 5.18.							

6.4 Data encoding and preamble

6.4.1 Data encoding

Manchester encoding shall be used for this mode to allow simple encoding/decoding and occupy a narrower baseband. Each bit shall be encoded as either a “10_b” chip sequence representing a “zero” or as a “01_b” representing a “one”. The lower frequency shall correspond to a chip value of “0_b”.

6.4.2 Order of transmission of the encoded data

Each data byte shall be transmitted with the MSBit first. The order of multi byte fields is defined in 12.2.

6.4.3 Preamble and synchronization pattern

The total preamble (header + synchronization) chip sequence for this mode shall be $n \times (01) 000111 011010010110$:

with $n \geq 279$ for the sub-mode S1 (long header)

with $n \geq 15$ for the sub-mode S1-m and S2 (short header)

with $n \geq 279$ for the sub-mode S2 optional long header

All chips of each frame, including pre- and postamble, shall form an uninterrupted sequence. After this preamble a frame of the format A shall follow.

NOTE In Manchester coding, the chip sequence 000111 is invalid but it is used near the end of the header to allow a receiver to detect the start of a new or a stronger transmission. This applies even during reception of a weaker transmission. The capture effect allows efficient communication even in a channel where many weak transmitters from a large area might otherwise effectively block the reception of a nearer (stronger) transmitter. In addition, it allows pulsed receivers to distinguish safely between the start of a valid frame and the detection of an accidental “sync” sequence within an ongoing transmission.

7 Mode T

7.1 Channel properties

The radio part of a meter shall, for all parameters, as a minimum conform to the requirements of ETSI EN 300 220-1 and ETSI EN 300 220-2 even if some applications require extended temperature or voltage range. The specific requirements for frequency bands are given in Table 7.

Table 7 — Mode T, Channel properties

Characteristic	Mode	min.	max.	Unit
Frequency band: M-2-O ^a	T1, T2	868,7	869,2	MHz
Frequency band: O-2-M	T2	868,0	868,6	MHz
^a This document is optimized for the 868 MHz to 870 MHz band, although with an appropriate transmission licence, other frequency bands could be used.				

NOTE See Figure A.1 and Figure A.2 for additional information on frequency and power recommendations.

7.2 Transmitter

The parameters for the transmitter shall be as given in Table 8.

Table 8 — Mode T, Transmitter

Characteristic	Mode	Symbol	min.	nom.	max.	Unit	Note
Centre frequency (M-2-O)	T1, T2		868,900	868,950	869,000	MHz	±60 ppm
Centre frequency (O-2-M)	T2		868,278	868,300	868,322	MHz	±25 ppm
FSK Deviation (M-2-O)	T1, T2		±40	±50	±80	kHz	
FSK Deviation (O-2-M)	T2		±40	±50	±80	kHz	
Chip rate transmit (M-2-O)	T1, T2	f_{chip2}	90	100	110	kcps	
Rate variation within header and frame (Meter)	T1, T2	D_{fchip}		0	±1	%	
Data rate ^a (M-2-O, 3 out of 6 encoding)	T1, T2	f_{chip2}		$f_{\text{chip}} \times 2/3$		bps	
Chip rate transmit (O-2-M)	T2			32,768		kcps	
Chip rate tolerance (O-2-M)	T2				±1,5	%	
Data rate (O-2-M, Manchester encoding)	T2			$f_{\text{chip2}} \times 1/2$		bps	
Preamble length including bit/byte-sync, both directions	T1, T2	PL	48			chips	
Postamble (trailer) length ^c	T1, T2		2		8	chips	
Response delay ^d (O-2-M communication)	T2	t_{RO}	2		3	ms	
FAC Transmission delay ^{e f}	T2	t_{TXD}	$N \times 1\,000 - 0,5$	$N \times 1\,000$	$N \times 1\,000 + 0,5$	ms	$N = 2, 3, \text{ or } 5$
FAC Time out ^b	T2	t_{TO}	25		30	s	

^a Each nibble (4 bits) shall be coded as 6 chips, see Table 10.

^b FAC Time out: is the time period between the last successful reception of a frame from the Other Device during the FAC and the moment where the repetition of the last response of the Meter shall be stopped (end of FAC).

^c The postamble (trailer) shall consists of at least two alternating chips. If the last chip of the CRC was a zero, then the minimum postamble shall be "10", otherwise it shall be "01".

^d Response delay: The receiver shall be ready for the reception of a response in a time shorter than the minimum response delay and shall be receiving at least until the maximum response delay (referred to the end of previous transmission).

^e FAC Transmission delay: describes the duration which a Meter shall delay the first response to a received message from Other Device referred to its last transmission. This delay shall also be applied between the first response of the Meter and the next repeated response of the Meter and all following repeated responses during the FAC. The reference time point shall be the end of preamble (end of sync sequence) of the Meter transmission. For timing diagrams see Annex E.

^f The selected timeslot N shall be the same throughout the FAC.

7.3 Receiver

The parameters for the receiver shall be as given in Table 9.

Table 9 — Receiver (T2 only)

Characteristic	Mode/ Class	Symbol	min.	nom.	max.	Unit	Note
Sensitivity (BER < 10 ⁻²) or (PER < 0,8)	H _R	P _o	-100	-105		dBm	Frame size of 20 bytes
Blocking performance ^a	M _R		2			Category	
Blocking performance ^a	H _R		2			Category	
Chip rate: (Meter)	T2	f _{chip}		32,76 8		kcps	
Acceptable header chip rate range: (Other Device)	T1, T2	f _{chip}	88	100	112	kcps	±12 %
Acceptable chip rate variation	T1, T2	D _{fchip}			±2	%	
^a Receiver category according to ETSI EN 300 220-1, V3.1.1:2017, 4.2.5.							

7.4 Data encoding and preamble

7.4.1 General

In mode T1 and mode T2, for optimum fast transmission, the data going from the meter to the reader device (Other Device) shall be encoded by the efficient “3 out of 6” code. In the mode T2, the reader may send back a message to the meter. This message shall be encoded using Manchester coding (see 8.4.1).

7.4.2 Meter transmit, “3 out of 6” data encoding

7.4.2.1 Coding rules

“3 out of 6” encoding shall be used for mode T1 and mode T2 to achieve an improved efficiency compared to Manchester encoding. Unique codes shall be used for specific control functions such as preamble, message start, etc. The encoding shall be performed as given in Table 10.

Each 4-bit nibble of data shall be encoded as a 6-bit pattern. Only those 6-bit patterns, out of the 64 combinations, with an equal number of zeros and ones and with a minimum of two transitions, have been selected.

The lower frequency shall correspond to a chip value of “0_b”.

Table 10 — Mode T, meter transmit, 3 out of 6 data encoding

NRZ-Code	Decimal	6-bit pattern	Decimal	Transitions
0000 _b	0	010110 _b	22	4
0001 _b	1	001101 _b	13	3
0010 _b	2	001110 _b	14	2
0011 _b	3	001011 _b	11	3
0100 _b	4	011100 _b	28	2
0101 _b	5	011001 _b	25	3
0110 _b	6	011010 _b	26	4
0111 _b	7	010011 _b	19	3
1000 _b	8	101100 _b	44	3
1001 _b	9	100101 _b	37	4
1010 _b	10	100110 _b	38	3
1011 _b	11	100011 _b	35	2
1100 _b	12	110100 _b	52	3
1101 _b	13	110001 _b	49	2
1110 _b	14	110010 _b	50	3
1111 _b	15	101001 _b	41	4

7.4.2.2 Order of transmission of the encoded data

The data coded as “3 out of 6” shall be transmitted with the MSBit (= left bit of the 6-bit pattern) first and with the most significant nibble (MSN) first.

Each data byte shall be transmitted with the MSBit first.

The order of multi byte fields is defined in 12.2

7.4.2.3 Preamble and synchronization pattern

The total preamble (header + synchronization) chips sequence for this mode shall be:

$$n \times (01) 0000111101_b \text{ with } n \geq 19.$$

After this preamble, a format A frame shall follow.

The chip sequence 0101010101_b has been reserved for the transmission preamble so that a receiver can start sampling at the maximum chip rate and then determine the actual chip rate from these patterns. Moreover, the high number of transitions ensures the best detection of the actual chip rate. Within the frame, the maximum number of contiguous zeroes or ones is four, but neither the pattern “00001111_b” nor the pattern “11110000_b” will ever occur inside a “3 out of 6” encoded chip sequence. The pattern can therefore be used for synchronization.

The chip sequence 0101010101_b will never occur within a valid frame. The decoder may use this to detect that the receiver has captured another transmission. In that case, the receiver shall stop the analysis of the current frame and start detecting a new frame. This “capture detection” feature increases the communication capacity of the system in presence of many users.

7.4.3 Other Device transmit, Manchester encoding

7.4.3.1 Coding rules

Manchester encoding shall be used for this mode to allow simple encoding/decoding and a narrow baseband. Each bit shall be encoded either as “10_b” chip sequence representing a “zero” or as “01_b” representing a “one”. The lower frequency shall correspond to a chip value of “0_b”.

7.4.3.2 Preamble and synchronization pattern

The total preamble (header + synchronization) chip sequence for this mode shall be $n \times (01) 000111 0110 1001 0110_b$ with $n \geq 15$. All chips of each frame, including pre- and postamble, shall form an uninterrupted sequence. After this preamble, a frame of the format A shall follow.

NOTE 1 In Manchester coding, the chip sequence 000111_b is invalid but it is used near the end of the header to allow a receiver to detect the start of a new or a stronger transmission. This applies even during reception of a weaker transmission. The capture effect allows efficient communication even in a channel where many weak transmitters from a large area might otherwise block the reception of a nearer (stronger) transmitter. In addition, it allows pulsed receivers to distinguish safely between the start of a valid frame and the detection of an accidental “sync” sequence within an ongoing transmission.

NOTE 2 The data encoding is the same as used in mode S and mode R2.

8 Mode R2

8.1 Channel properties

The radio part of a meter shall, for all parameters, as a minimum conform to the requirements of ETSI EN 300 220-1 and ETSI EN 300 220-2, even if some application requires extended temperature or voltage range. The specific requirements for frequency band and channel spacing are given in Table 11.

Table 11 — Mode R2, Channel properties

Characteristic	min.	nom.	max.	Unit
Frequency band ^a	868,00		868,60	MHz
Channel spacing		60		kHz
^a This document is optimized for the 868 MHz to 870 MHz band, although with an appropriate transmission licence, other frequency bands could be used.				

NOTE See Figure A.1 and Figure A.2 for additional information on frequency and power recommendations.

8.2 Transmitter

The parameters for the transmitter shall be as listed in Table 12.

Table 12 — Mode R2, Transmitter

Characteristic	Symbol	min.	nom.	max.	Unit	Note
Centre frequency (Other Device)			868,330		MHz	
Centre frequency (Meter)			868,030 $+n \times 0,06$		MHz	
Frequency tolerance (Meter/Other Device)				± 17	kHz	± 20 ppm
FSK Deviation		$\pm 4,8$	± 6	$\pm 7,2$	kHz	
Chip rate (wakeup and communications)			4,8		kcps	
Chip rate tolerance (wakeup and communications)				$\pm 1,5$	%	
Data rate (Manchester encoding) ^b			$f_{\text{chip}} \times$ $1/2$		bps	
Preamble length including bit/byte-sync	PL	96			chips	
Postamble (trailer) length ^c		2		8	chips	
Response delay (O-2-M communication)	t_{RO}	3		50	ms	
Response delay ^d (M-2-O)	t_{RM}	10		10 000	ms	
FAC Transmission delay ^{e f}	t_{TxD}	$N \times$ $1000 - 1$	$N \times 1\,000$	$N \times$ $1\,000 + 1$	ms	$N = 5, 7 \text{ or } 13$
FAC Time out ^a	t_{TO}	25		30	s	

^a FAC Time out: is the time period between the last successful reception of a frame from the Other Device during the FAC and the moment where the repetition of the last response of the Meter shall be stopped (end of FAC).

^b Each bit shall be coded as 2 chips (Manchester encoding).

^c The postamble (trailer) shall consists of $1 \leq n \leq 4$ "ones" i.e. the chip sequence shall be $n \times (01)$.

^d Response delay: The receiver shall be ready for the reception of a response in a time shorter than the minimum response delay and shall be receiving at least until the maximum response delay (referred to the end of previous transmission). The response delay t_{RO} shall be used if the CI-field of received frame is 81_{h} , otherwise the response delay t_{RM} shall be used.

^e FAC Transmission delay: describes the duration which a Meter shall delay the first response to a received message from the Other Device referred to its last transmission. This delay shall also be applied between the first response of the Meter and the next repeated response of the Meter and all following repeated responses during the FAC. The reference time point shall be the end of preamble (end of sync sequence) of the Meter transmission.

^f The selected timeslot N shall be the same throughout the FAC.

8.3 Receiver

The parameters for the receiver shall be as listed in Table 13.

Table 13 — Mode R2, Receiver

Characteristic	Class	Symbol	min.	nom.	max.	Unit	Note
Sensitivity (BER < 10 ⁻²) or (PER < 0,8)	H_R	P_o	-105	-110		dBm	At a frame size of 20 bytes
Blocking performance ^a	M_R		2			Category	
Blocking performance ^a	H_R		2			Category	
Acceptable chip rate range		f_{chip}	4,7	4,8	4,9	kcps	approx. ± 2 %
Acceptable chip rate variation during header and frame		D_{fchip}			±0,2	%	
Adjacent channel selectivity ^b	H_R		40			dB	
^a Receiver category shall be according to ETSI EN 300 220-1 V3.1.1:2017, 4.2.5.							
^b Adjacent channel selectivity measured according to ETSI EN 300 220-1, V3.1.1:2017, 5.15.							

8.4 Data encoding and preamble

8.4.1 Data encoding

Manchester encoding shall be used for this mode to allow simple encoding/decoding and a narrow baseband. Each bit shall be encoded either as a “10_b” chip sequence representing a “zero” or as a “01_b” representing a “one”. The lower frequency corresponds to a chip value of “0_b”.

8.4.2 Order of transmission of the encoded data

Each data byte shall be transmitted with the MSBit first.

The order of multi byte fields is defined in 12.2.

8.4.3 Preamble and synchronization pattern

The total preamble (header + synchronization) chip sequence for this mode shall be $n \times (01) 000111 0110 1001 0110_{\text{b}}$ with $n \geq 39$. All chips of each frame shall form an uninterrupted chip sequence. After this preamble, a frame of the format A shall follow.

NOTE 1 In Manchester coding, the chip sequence 000111_b is invalid, but it is used near the end of the header to allow a receiver to detect the start of a new or a stronger transmission. This applies even during reception of a weaker transmission. The capture effect allows efficient communication even in a channel where many weak transmitters from a large area might otherwise effectively block the reception of a nearer (stronger) transmitter. In addition, it allows pulsed receivers to distinguish safely between the start of a valid frame and the detection of an accidental “sync” sequence within an ongoing transmission.

NOTE 2 The data encoding is the same as used in mode S and mode T2.

9 Mode C

9.1 Channel properties

The radio part of a meter shall, for all parameters, as a minimum conform to the requirements of ETSI EN 300 220-1 and ETSI EN 300 220-2, even if some applications require extended temperature or voltage range. The specific requirements for frequency bands are given in Table 14.

Table 14 — Mode C, Channel properties

Characteristic	Mode	min.	max.	Unit
Frequency band: M-2-O ^a	C1, C2	868,7	869,2	MHz
Frequency band: O-2-M ^a	C2	869,4	869,65	MHz
^a This document is optimized for the 868 MHz to 870 MHz band, although with an appropriate transmission licence, other frequency bands could be used.				

9.2 Transmitter

The parameters for the transmitter shall be as listed in Table 15.

Table 15 — Mode C, Transmitter

Characteristic	Mode	Symbol	min.	nom.	max.	Unit	Note
Centre frequency (M-2-O)	C1, C2		868,928	868,950	868,972	MHz	±25 ppm
Centre frequency (O-2-M)	C2		869,503	869,525	869,547	MHz	±25 ppm
FSK Deviation ^a (M-2-O)	C1, C2		±33,75	±45	±56,25	kHz	75 % to 125 % of nominal deviation
GFSK Deviation ^a (O-2-M)	C2		±18,75	±25	±31,25	kHz	75 % to 125 % of nominal deviation
GFSK relative bandwidth	C2	BT		0,5			
Chip rate (M-2-O)	C1, C2	f_{chip}		100		kcps	
Chip rate (O-2-M)	C2	f_{chip}		50		kcps	
Chip rate tolerance	C1, C2				±100	ppm	
Data rate ^b	C1, C2			f_{chip}		bps	
Preamble length ^c	C1, C2	PL	32		32	chips	
Synchronization length	C1, C2	SL	32		32	chips	
Fast response delay ^{d e f} (default) (O-2-M)	C2	t_{RO}	99,5	100	100,5	ms	
Slow response delay ^{d e f} (O-2-M)	C2	$t_{\text{RO_slow}}$	999,5	1 000	1 000,5	ms	
Fast response delay ^{d e} (default) (M-2-O)	C2	t_{RM}	99,5	100	100,5	ms	

Characteristic	Mode	Symbol	min.	nom.	max.	Unit	Note
Slow response delay ^{d e} (M-2-O)	C2	t_{RM_slow}	999,5	1 000	1 000,5	ms	
FAC Transmission delay ^{g h}	C2	t_{TxD}	$N \times 1\,000 - 0,5$	$N \times 1\,000$	$N \times 1\,000 + 0,5$	ms	$N = 2,3 \text{ or } 5$
FAC Time out ⁱ	C2	t_{TO}	25		30	s	
^a Deviation (min./max. values) are specified in the centre of the chip or symbol for a pseudo random sequence transmission. ^b All bits are NRZ coded. ^c The first three chips of the preamble may, if needed, be used for power ramping. ^d After receiving a frame the responding unit shall start the transmission of preamble after the specified response delay. The response delay is measured from the reception time of the last bit of the frame. For timing diagrams see Annex E. ^e The use of slow or fast response delay is specified in the “Communication Control Field” of the Extended Link Layer – refer to 13.2.7. For timing diagrams see Annex E. If an Extended Link Layer is not included in the frame, the default response delay shall be used. ^f If the frame is repeated (specified in the “Communication Control Field” of the Extended Link Layer – refer to 13.2.7) the Other Device shall instead use a shorter response delay (t_{RR} or t_{RR_slow}) being 85 ms shorter than the corresponding t_{RO} or t_{RO_slow}. This enables bi-directional communication to be repeated without loss of communication speed. The frame from meter to the Other Device shall be repeated with a delay less than 5 ms (t_{DRFE}). For timing diagrams see Annex E. ^g FAC Transmission delay: This delay shall be applied between the first response of the meter and the next repeated response of the meter and all following repeated responses during the FAC. The reference time point shall be the end of preamble (end of sync sequence) of the meter transmission. For timing diagrams see Annex E. ^h The selected timeslot N shall be the same throughout the FAC. ⁱ FAC Time out: This is the time period between the last successful reception of a frame from the Other Device during the FAC and the moment where the repetition of the last response of the meter shall be stopped (end of FAC).							

9.3 Receiver

The parameters for the receiver shall be as listed in Table 16.

Table 16 — Mode C, Receiver

Characteristic	Class	Symbol	min.	nom.	max.	Unit	Note
Sensitivity (BER < 10 ⁻²) or (PER < 0,8) (Other Device)	H_R	P_o	-100	-105		dBm	Frame size 20 bytes
Sensitivity (BER < 10 ⁻²) or (PER < 0,8) (Meter)	H_R	P_o	-95			dBm	Frame size 20 bytes
Blocking performance ^a	M_R		2			Category	
Blocking performance ^a	H_R		2			Category	
^a Receiver category according to ETSI EN 300 220-1, V3.1.1:2017, 4.2.5.							

9.4 Data encoding and preamble

9.4.1 Encoding

All communication from the Meter to the Other Device is transmitted as FSK modulated data. FSK has been selected to allow for reception of mode C and mode T frames in the same receiver. All communication from the Other Device to the Meter is transmitted as GFSK modulated data. All communication is NRZ-encoded, with the low frequency corresponding to a binary '0'.

Each data byte shall be transmitted with the MSBit first.

The order of multi byte fields is defined in 12.2.

9.4.2 Preamble and synchronization pattern

All communication shall be preceded by either

- a) $n \times (01) 0101010000111101 01010100 11001101_b$, or
- b) $n \times (01) 0101010000111101 01010100 00111101_b$, with $n = 16$.

The first 16 chips of the synchronisation pattern are equal to preamble + synchronisation pattern of mode T. This makes it possible to implement one decoder being able to decode both frames of mode T and frames of mode C. If the frame is of mode C, the next 6 chips will form the pattern "010101_b". The decoder may use this to detect that the received frame is not of mode T since the pattern "010101_b" will never occur inside the "3 out of 6" encoded chip sequence used in mode T. The last 8 chips decide about the selected frame format. If the pattern of the last 8 chips equals to "11001101_b" the frame format A follows. If the pattern of the last 8 chips equals to "00111101_b" the frame format B follows (refer to 12.4).

The decoder may optionally detect that the receiver has captured another transmission, by detecting a new preamble and synchronization sequence in conjunction with an abrupt increase in the received signal strength. In that case, the receiver shall stop the analysis of the current frame and start detecting a new frame. This "capture detect" feature increases the communication capacity of the system in presence of many users.

10 Mode N

10.1 Channel properties

The radio part of a meter shall, for all parameters, as a minimum conform to the requirements of ETSI EN 300 220-1, ETSI EN 300 220-2 and ETSI EN 300 220-4 even if some applications require extended temperature or voltage range. There are individual requirements for frequency range, duty cycle and channel spacing for the different sub bands. They are given in Table 17, Table 18, Table 19 and Table 20. An overview of this is found in Annex B.

Table 17 — Mode N, Channel properties, sub-band A

Characteristic	min.	nom.	max.	Unit
Frequency band ^a	169,400		169,475	MHz
Channel spacing		12,5/25/50	50	kHz
Transmitted power			500	mW
Transmitter duty cycle			10	%

Characteristic	min.	nom.	max.	Unit
^a This document is optimized for the 169 MHz band, although with an appropriate transmission licence, other frequency bands could be used.				

Table 18 — Mode N, Channel properties, sub-band B

Characteristic	min.	nom.	max.	Unit
Frequency band ^a	169,475		169,487 5	MHz
Channel spacing		12,5		kHz
Transmitted power			10	mW
Transmitter duty cycle ^b			0,1	%
^a This document is optimized for the 169 MHz band, although with an appropriate transmission licence, other frequency bands could be used.				
^b National legislation can be less restrictive.				

Table 19 — Mode N, Channel properties, sub-band C

Characteristic	min.	nom.	max.	Unit
Frequency band ^a	169,487 5		169,587 5	MHz
Channel spacing		12,5/25/50		kHz
Transmitted power			10	mW
Transmitter duty cycle ^{b c}			0,001	%
NOTE For this sub-band ERC/REC 70-03 states: Equipment that concentrates or multiplexes individual equipment is excluded. Individual national legislation can be less restrictive.				
^a This document is optimized for the 169 MHz band, although with an appropriate transmission licence, other frequency bands could be used.				
^b Between 00:00 and 06:00 local time a duty cycle limit of 0,1 % may be used.				
^c National legislation can be less restrictive.				

Table 20 — Mode N, Channel properties, sub-band D

Characteristic	min.	nom.	Max.	Unit
Frequency band ^a	169,587 5		169,812 5	MHz
Channel spacing		12,5		kHz
Transmitted power			10	mW
Transmitter duty cycle ^b			0,1	%
^a This document is optimized for the 169 MHz band, although with an appropriate transmission licence, other frequency bands could be used.				
^b National legislation can be less restrictive.				

10.2 Physical link parameters

The sub modes shall be allocated to the channels and frequencies as given in Table 21.

Table 21 — Mode N, Frequencies, and channels

Sub-band	Index	Centre frequency MHz	Channel spacing kHz	GFSK kbps	4 GFSK kbps	Frequency tolerance kHz	Channel range
A	1	$169,406\,25 + n \times 0,0125$	12,5	2,4		$\pm 2,0$	$0 \leq n \leq 5$
A	2	$169,406\,25 + n \times 0,0125$	12,5	4,8		$\pm 1,5$	$0 \leq n \leq 5$
A	3	$169,406\,25 + n \times 0,0125$	12,5		6,4	$\pm 1,5$	$0 \leq n \leq 5$
A	4	169,437 5	50		19,2	$\pm 2,5$	$n = 0$
B	5	169,481 25	12,5	2,4		$\pm 2,0$	$n = 0$
B	6	169,481 25	12,5	4,8		$\pm 1,5$	$n = 0$
C	7	$169,493\,75 + n \times 0,0125$	12,5	2,4		$\pm 1,5$	$0 \leq n \leq 7$
C	8	$169,493\,75 + n \times 0,0125$	12,5	4,8		$\pm 1,5$	$0 \leq n \leq 7$
C	9	$169,493\,75 + n \times 0,0125$	12,5		6,4	$\pm 1,5$	$0 \leq n \leq 7$
D	10	$169,593\,75 + n \times 0,0125$	12,5	2,4		$\pm 2,0$	$0 \leq n \leq 17$
D	11	$169,593\,75 + n \times 0,0125$	12,5	4,8		$\pm 1,5$	$0 \leq n \leq 17$
D	12	$169,593\,75 + n \times 0,0125$	12,5		6,4	$\pm 1,5$	$0 \leq n \leq 17$
D	13	$169,625 + n \times 0,05$	50		19,2	$\pm 2,5$	$0 \leq n \leq 3$
NOTE Uplink and downlink messages may use a different channel and/or modulation.							

The modulation and timing shall be as given in Table 22.

Table 22 — Mode N, Modulation, and timing

Characteristic	Data rate	Symbol	min.	nom.	max.	Unit	Note
GFSK, deviation (mod. index 2,0)	2,4 kbps		±1,68	±2,4	±3,12	kHz	70 % to 130 % of nominal freq. deviation ^a
GFSK, deviation (mod. index 1,0)	4,8 kbps		±1,68	±2,4	±3,12	kHz	70 % to 130 % of nominal deviation ^a
4GFSK, deviation (mod. index 1,0)	6,4 kbps		±2,24	-3,2, -1,06, +1,06, +3,2	±4,16	kHz	70 % to 130 % of nominal deviation ^a
4GFSK, deviation (mod. index 0,5)	19,2 kbps		±5,04	-7,2, -2,4, +2,4, +7,2	±9,36	kHz	70 % to 130 % of nominal deviation ^a
GFSK/4GFSK relative bandwidth	All	BT		0,5			
Bit/symbol rate tolerance	All				±100	ppm	
Preamble length	All	PL	16 ^f		16 ^f	bits or symbols	
Synchronization length	All	SL	16		16	bits or symbols	
Postamble (trailer) length	All			0		bits or symbols	
Fast response delay ^b (O-2-M)	All	t_{RO}	99,5	100	100,5	ms	
Slow response delay ^b (O-2-M)	4,8 kbps 6,4 kbps 19,2 kbps	t_{RO_slow}	1 099,5 1 099,5 1 099,5	1 100 1 100 1 100	1 100,5 1 100,5 1 100,5	ms	
Slow response delay ^b (O-2-M)	2,4 kbps	t_{RO_slow}	2 099,5	2 100	2 100,5	ms	
Extended response delay (default) ^{b g} (O-2-M)	All	t_{RO_extd}	4 997,5	5 000	5 002,5	ms	
FAC transmission delay ^{c d}		t_{TxD}	$N \times 1\ 000 - 0,5$	$N \times 1\ 000$	$N \times 1\ 000 + 0,5$	ms	$N = 5,7 \text{ or } 13^h$
FAC time out ^e	All	t_{TO}	25		30	s	

NOTE Continuous phase modulation is recommended for all modulations to support coherent demodulation.

^a Deviation (min./max. values) are specified in the centre of the chip or symbol for a pseudo random sequence transmission.

^b The transmitter shall start transmitting the preamble within this time delay after last bit of received frame. The use of slow, fast or extended response delay is specified in the "Communication Control Field" of the Extended Link Layer – refer to 13.2.7.3. For timing diagrams see Annex E. If an Extended Link Layer is not present, the default response delay shall be used.

^c FAC Transmission delay: describes the duration which a Meter shall delay the first response to a received message from an Other Device referred to its last transmission. This delay shall also be applied between the first response of the Meter and the next repeated response of the Meter and all following repeated responses during the FAC. The reference time point shall