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English Version

Communication systems for meters - Part 4: Wireless M-Bus communication

Systèmes de communication pour compteurs - Partie 4 : Communication sans fil M-Bus

Kommunikationssysteme für Zähler - Teil 4: Drahtlose M-Bus-Kommunikation

This European Standard was approved by CEN on 25 February 2019.

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CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

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European foreword

This document (EN 13757-4:2019) 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of an identical text or by endorsement, at the latest by November 2019, and conflicting national standards shall be withdrawn at the latest by November 2019.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 13757-4:2013.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

The main changes since EN 13757-4:2013 are as follows:

— Referenced standards have been updated to the most recent versions;

— Mode N, in the 169 MHz band has been extended to cover more frequencies see Clause 10;

— New C-field function code (Send User Data – No reply) added see 12.5.4;

— Extended timing tolerances for synchronous transmission see 12.6.2;

— Optional Forward Error Correction in the Link Layer added see 12.8;

— CI field for selectable Extended Link Layer added see 13.2;

— Management functions for link control added see Clause 14.

The standard 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. The standard 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. The standard does not specify any of the metering capabilities of the meter nor the metrological capabilities of the meter.

The standard 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.

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

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, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

This European Standard 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 13757-6 describes a twisted pair local bus for short distance (Lo-Bus).

EN 13757-7 describes transport and security services.

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 that 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 wireless 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 standard 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.

The 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 given in 12.8.

CEN takes no position concerning the evidence, validity and scope of this patent right.

The holder of this patent right has ensured CEN that he/she is willing to negotiate licences either free of charge or under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with CEN. Information may be obtained from:

Kamstrup A/S

Rasmus Søby Dupont, IP Manager, Technology

Industrivej 28, Stilling

8660 Skanderborg

Denmark

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CEN and CENELEC maintain online lists of patents relevant to their standards. Users are encouraged to consult the lists for the most up to date information concerning patents (ftp://ftp.cencenelec.eu/EN/IPR/Patents/IPRdeclaration.pdf).

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 telemetry bands. The standard encompasses systems for walk-by, drive-by and fixed installations. As a broad definition, this European Standard 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 13757-2, *Communication systems for meters - Part 2: Wired M-Bus communication*

EN 13757-3:2018, *Communication systems for meters - Part 3: Application protocols*

EN 13757-5:2015, *Communication systems for meters - Part 5: Wireless M-Bus relaying*

EN 13757-7:2018, *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, V3.2.1:2018-04, *Short Range Devices (SRD) operating in the frequency range 25 MHz to 1 000 MHz — Part 2: Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU for non specific radio equipment*

ETSI EN 300-220−4, V1.1.1:2017, *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*

Draft ETSI EN 301 489−1, V2.2.0:2017, *ElectroMagnetic Compatibility (EMC) standard for radio equipment and services — Harmonised Standard covering the essential requirements of article 3.1(b) of the Directive 2014/53/EU and the essential requirements of article 6 of the Directive 2014/30/EU — Part 1: Common technical requirements*

ETSI EN 301-489−3, *Electromagnetic compatibility and Radio spectrum Matters (ERM) — ElectroMagnetic Compatibility (EMC) standard for radio equipment and services — Part 3: Specific conditions for Short-Range Devices (SRD) operating on frequencies between 9 kHz and 246 GHz*

CCSDS 131.*0-B-2 (Consultative Committee for Space Data Systems (CCSDS)), August 2011,* Recommended standard for TM Synchronization and Channel Coding*, Issue 2*

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 2018-10-05

3 Terms and definitions

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

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

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

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
GFSK
gaussian frequency shift keying

3.6
individual transmission interval
exact time between two subsequent synchronous or periodical transmissions which changes with each transmission

3.7
LSB
least significant byte

3.8
LSBit
least significant bit

3.9
message
set of data at the Application Layer

3.10
MSB
most significant byte

3.11
MSBit
most significant bit

3.12
nominal transmission interval
average individual transmission interval between all synchronous or periodical messages (new, old or no data content) for wireless meters

3.13
NRZ
non-return-to-zero

3.14
other device
end 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.

3.15
PER
packet error rate

3.16
PN9
nine bit pseudo-random pattern

Note 1 to entry: The PN9 needs to be designed according to ITU-T Rec. O.150.

4 Abbreviations and symbols

4.1 Abbreviation

CI	Control Information Field
Ident no.	Identification number (serial number) (part of meter address)
Manuf.	Manufacturer acronym (part of meter address)
Ver.	Version (part of meter address)
Device Type	Device type (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
typ.	typical value
max.	maximum value
RFU	Reserved for Future Use

4.2 Symbols

Hexadecimal notation is designated by a following “$_h$”.

Binary numbers are designated by a following “$_b$”.

Decimal numbers have no suffix.

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 response is a reverse channel 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 common 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 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.

The detailed handling of broadcast and multicast transmissions is not specified in this standard. The transmission shall be interpreted as multicast if no Extended Link Layer or Transport Layer is used.

5.2 Meter communications 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 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 unit 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 (short frame meters)	100	0,1 %	3 to 6 and short header	Transmit only with short data bursts typically 3 ms to 8 ms every few seconds, operates in a 0,1 % duty cycle frequency band.

Modes and sub-modes	WAY	Typical use	Chip-rate kcps	Maximum duty cycle[a]	Data coding and header	Description
T2	2	Frequent transmission (short frame meter with two way capability)	M-2-O: 100 O-2-M: 32,768	0,1 %	3 to 6 and short header Manchester and short header	Meter unit 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 S2 acknowledge (at 32,768 kcps) is received. Further bidirectional communication using mixed T1 – S2 mode may follow.
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 < 22 ms, operates in a 0,1 % duty cycle frequency band.
C2	2	Frequent transmit meter for mobile or stationary readout	M-2-O: 100 O-2-M: 50	M-2-O: 0,1 % O-2-M: 10 %	M-2-O:NRZ, short header O-2-M: NRZ short header	Meter unit 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.
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 unit 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 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 2013/752/EU.

5.3 Performance Classes

The transmitters shall belong to one of three Classes ranging from low and medium to high radiated power (see Table 2).

The maximum allowable radiated power for the transmitter is defined according to ERC/REC 70-03 or as permitted by local radio regulation. 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.

When existing, the receiver shall belong to one of three Classes in sensitivity and blocking performance; from low and medium to high (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}
L_{T}	Lowest performance	Limited transmission power	Both	−5 dBm (all but mode N) 0 dBm (mode N)
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-O	+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
L_{R}	Lowest performance	Limited sensitivity, minimum blocking performances	−80 dBm (mode R,S,T,C) −90 dBm (mode N) −105 dBm (mode F)
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 20 and Table 23

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.

Table 4 — Mode S, Channel properties

Characteristic	Min	Typical	Max	Unit
Frequency band[a]	868,0	868,3	868,6	MHz
Transmitter duty cycle S2[b]		0,02	1	%
Transmitter duty cycle S1 and S1-m[c]			0,02	%

[a] This European Standard 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 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.	typ.	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	%	
Digital bit jitter[a]					±3	us	
Data rate (Manchester)[b]				$f_{chip} \times 1/2$		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[d h] (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,or 5
FAC Time out[g]	S2	t_{TO}	25		30	s	

Characteristic	Mode	Symbol	min.	typ.	max.	Unit	Note

[a] The bit jitter shall be measured at the output of the micro-controller or encoder circuit.

[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 × (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 Frequent Access Cycle (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 Frequent Access Cycle (FAC) and the moment where the repetition of the last response of the Meter shall be stopped (end of Frequent Access Cycle).

[h] EN 13757-4:2013 applies a maximum Response delay O-2-M of 50 ms.

6.3 Receiver

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

Table 6 — Receiver

Characteristic	Class	Symbol	min.	typ.	max.	Unit	Note
Sensitivity (BER < 10^{-2}) or (PER < 0,8)[a]	H_R	P_o	−100	−105		dBm	
Blocking performance[b]	L_R		2[e]			Category	
Blocking performance[b c]	M_R		2			Category	
Blocking performance[b c d]	H_R		2			Category	
Acceptable chip rate tolerance		D_{fchip}			±2	%	
Chip rate (Meter)		f_{chip}		32,768		kcps	

[a] At a frame size of 20 bytes.

[b] Receiver blocking performance according to ETSI EN 300 220–1, V3.1.1:2017, 5.18.

[c] Additional requirement for Class M_R and Class H_R receivers: The equipment shall meet the immunity requirements as specified in Draft ETSI EN 301 489–1, V2.2.0:2017.

[d] Additional requirement for Class H_R receivers: Adjacent channel selectivity shall be > 40 dB when measured according to ETSI EN 300 220–1, V3.1.1:2017, 5.15.

[e] Blocking performance category 3 is no more sufficient.

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 base-band. 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 most significant bit 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 × (01) 000111 011010010110:

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

with $n \geq 15$ for the sub-mode 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.	typ.	max.	Unit
Frequency band: M-2-O[a]	T1, T2	868,7	868,95	869,2	MHz
Frequency band: O-2-M	T2	868,0	868,3	868,6	MHz

[a] This European Standard is optimized for the 868 MHz to 870 MHz band, although with an appropriate transmission licence, other frequency bands could be used.

NOTE Figure A.1 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.	typ.	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	%	
Digital bit jitter[b]	T2				±3	µs	
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, or 5
FAC Time out[g]	T2	t_{TO}	25		30	s	

Characteristic	Mode	Symbol	min.	typ.	max.	Unit	Note

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

[b] The bit jitter shall be measured at the output of the microprocessor or encoder circuit.

[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 Frequent Access Cycle (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 Frequent Access Cycle (FAC) and the moment where the repetition of the last response of the Meter shall be stopped (end of Frequent Access Cycle).

7.3 Receiver (T2 only)

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

Table 9 — Receiver (T2 only)

Characteristic	Mode/Class	Symbol	min.	typ.	max.	Unit	Note
Sensitivity (BER < 10^{-2}) or (PER < 0,8)[a]	H_R	P_o	−100	−105		dBm	
Blocking performance[b]	L_R		2[e]			Category	
Blocking performance[b c]	M_R		2			Category	
Blocking performance [c d]	H_R		2			Category	
Acceptable header chip rate range: (Other Device)	T1, T2	f_{chip}	88	100	112	kcps	±12 %
Acceptable chip rate variation during header and frame: (Other Device)	T1, T2	D_{fchip}		0	±2	%	
Chip rate: (Meter)	T2	f_{chip}		32,768		kcps	
Acceptable chip rate variation (Meter)	T2	D_{fchip2}		0	±2	%	

[a] At a frame size of 20 bytes.

[b] Receiver category according to ETSI EN 300 220–1, V3.1.1:2017, 4.2.5.

[c] Additional requirement for Class M_R and Class H_R receivers: The equipment shall meet the immunity requirements as specified in Draft ETSI EN 301 489–1, V2.2.0:2017, 9.2.

[d] Additional requirement for Class H_R receivers: Adjacent channel selectivity shall be > 40 dB when measured according to ETSI EN 300 220–1, V3.1.1:2017, 5.15.

[e] Blocking performance category 3 is no more sufficient.

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 word. Only those words, 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 code	Decimal	N° of 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 most significant bit (MSBit = Left bit of the 6-bit code) first and with the most significant nibble (MSN) first.

Each data byte shall be transmitted with the most significant bit 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:

$n \times (01)\ 0000111101_b$ 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 during a normal chip sequence. 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 detect” 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 base-band. 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 × (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 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 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.	typ.	max.	Unit
Frequency band[a]	868,00	868,33	868,60	MHz
Channel spacing		60		kHz

[a] This European Standard 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 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.	typ.	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)			0	±17	kHz	±20 ppm
FSK Deviation		±4,8	±6	±7,2	kHz	
Chip rate (wakeup and communications)			4,8		kcps	
Chip rate tolerance (wakeup and communications)			0	±1,5	%	
Digital bit jitter [a]				±15	µs	
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 or 13
FAC Time out[g]	t_{TO}	25		30	s	

a The bit jitter shall be measured at the output of the micro-controller or encoder circuit.

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

c The postamble (trailer) shall consists of $1 \le n \le 4$ “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 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 Frequent Access Cycle (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 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 Frequent Access Cycle (FAC) and the moment where the repetition of the last response of the Meter shall be stopped (end of Frequent Access Cycle).

8.3 Receiver

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

Table 13 — Mode R2, Receiver

Characteristic	Class	Symbol	min.	typ.	max.	Unit	Note
Sensitivity (BER < 10^{-2}) or (PER < 0,8)[a]	H_R	P_o	−105	−110		dBm	
Blocking performance[b]	L_R		2[e]			Category	
Blocking performance[b c]	M_R		2			Category	
Blocking performance[b c d]	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	±0,2	%	

[a] At a frame size of 20 bytes.

[b] Receiver category shall be according to ETSI EN 300 220–1 V3.1.1:2017, 4.2.5.

[c] Additional requirement for Class M_R and Class H_R receivers: The equipment shall meet the immunity requirements as specified in Draft ETSI EN 301 489–1, V2.2.0:2017, 9.2.

[d] Additional requirement for Class H_R receivers: Adjacent channel selectivity shall be > 40 dB when measured according to ETSI EN 300 220–1, V3.1.1:2017, 5.15.

[e] Blocking performance category 3 is no more sufficient.

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 base-band. 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 most significant bit 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 × (01) 000111 0110 1001 0110_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.	typ.	max.	Unit
Frequency band: M-2-O[a]	C1, C2	868,7	868,95	869,2	MHz
Frequency band: O-2-M[a]	C2	869,4	869,525	869,65	MHz
[a] This European Standard 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.	typ.	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	
GFSK Deviation[a] (O-2-M)	C2		±18,75	±25	±31,25	kHz	
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_{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	
Slow response delay[d e] (M-2-O)	C2	t_{RM_slow}	999,5	1 000	1 000,5	ms	

Characteristic	Mode	Symbol	min.	typ.	max.	Unit	Note
FAC Transmission delay[g h]	C2	t_{TxD}	N × 1 000 −0,5	N × 1 000	N × 1 000 +0,5	ms	N = 2,3 or 5
FAC Time out[i]	C2	t_{TO}	25		30	s	

[a] 75 % to 125 % of nominal deviation measured in centre of chip (frequency vs. time eye opening) transmitting a 9 bit pseudo-random (PN9) sequence, min./max. based on the root-mean-square (rms) error value.

[b] All bits are NRZ coded.

[c] The first three symbols 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 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 Frequent Access Cycle (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 Frequent Access Cycle.

[i] FAC Time out: This is the time period between the last successful reception of a frame from the Other Device during the Frequent Access Cycle (FAC) and the moment where the repetition of the last response of the meter shall be stopped (end of Frequent Access Cycle).

9.3 Receiver

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

Table 16 — Mode C, Receiver

Characteristic	Class	Symbol	min.	typ.	max.	Unit
Sensitivity (BER < 10^{-2}) or (PER < 0,8) (Other Device)[a]	H_R	P_o	−100	−105		dBm
Sensitivity (BER < 10^{-2}) or (PER < 0,8) (Meter)[a]	H_R	P_o	−95			dBm
Blocking performance[b]	L_R		2[e]			Category
Blocking performance[b c]	M_R		2			Category
Blocking performance[b c d]	H_R		2			Category

a At a frame size of 20 bytes.

b Receiver category according to ETSI EN 300 220–1, V3.1.1:2017, 4.2.5.

c Additional requirement for Class M_R and Class H_R receivers: The equipment shall meet the immunity requirements as specified in Draft ETSI EN 301 489–1, V2.2.0:2017, 9.2 and in ETSI EN 301 489–3.

d Additional requirement for Class H_R receivers: Adjacent channel selectivity shall be > 40 dB when measured according to ETSI EN 300 220–1, V3.1.1:2017, 5.15.

e Blocking performance category 3 is no more sufficient.

9.4 Data encoding and preamble

9.4.1 Encoding

All communication from Meter to Other Device is transmitted as FSK modulated data. All communication from Other Device to 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 most significant bit 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 × (01) 0101010000111101 01010100 11001101_b, or

b) n × (01) 0101010000111101 01010100 00111101_b, with n = 16.

The first 16 chips of the synchword are equal to preamble + synchword 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.	typ.	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	%

[a] This European Standard 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.	typ.	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 European Standard is optimized for the 169 MHz band, although with an appropriate transmission licence, other frequency bands could be used.

[b] National legislation may be less restrictive.

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

Characteristic	min.	typ.	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 subband ERC/REC 70-03 states: Equipment that concentrates or multiplexes individual equipment is excluded. Individual national legislation may be less restrictive.

[a] This European Standard 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 may be less restrictive.

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

Characteristic	min.	typ.	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 European Standard is optimized for the 169 MHz band, although with an appropriate transmission licence, other frequency bands could be used.

[b] National legislation may 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	Center frequency MHz	Channel spacing kHz	GFSK kbps	4 GFSK kbps	Frequency tolerance kHz	Channel range
A	1	169,406 25 + n × 0,0125	12,5	2,4		±2,0	0 ≤ n ≤ 5
A	2	169,406 25 + n × 0,012 5	12,5	4,8		±1,5	0 ≤ n ≤ 5
A	3	169,406 25 + n × 0,012 5	12,5		6,4	±1,5	0 ≤ n ≤ 5
A	4	169,437 5	50		19,2	±2,5	n = 0
B	5	169,481 25	12,5	2,4		±2,0	n = 0
B	6	169,481 25	12,5	4,8		±1,5	n = 0

Sub-band	Index	Center frequency MHz	Channel spacing kHz	GFSK kbps	4 GFSK kbps	Frequency tolerance kHz	Channel range
C	7	169,493 75 + n × 0,012 5	12,5	2,4		±1,5	0 ≤ n ≤ 7
C	8	169,493 75 + n × 0,012 5	12,5	4,8		±1,5	0 ≤ n ≤ 7
C	9	169,493 75 + n × 0,012 5	12,5		6,4	±1,5	0 ≤ n ≤ 7
D	10	169,593 75 + n × 0,012 5	12,5	2,4		±2,0	0 ≤ n ≤ 17
D	11	169,593 75 + n × 0,012 5	12,5	4,8		±1,5	0 ≤ n ≤ 17
D	12	169,593 75 + n × 0,012 5	12,5		6,4	±1,5	0 ≤ n ≤ 17
D	13	169,625 + n × 0,05	50		19,2	±2,5	0 ≤ n ≤ 3

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

Table 22 — Mode N, Modulation and timing

Characteristic	Data rate	Symbol	min.	typ.	max.	Unit	Note
GFSK, deviation (mod. index 2,0)	2,4 kbps		±1,68	±2,4	±3,12	kHz	70 % to 130 % of nominal 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	

Characteristic	Data rate	Symbol	min.	typ.	max.	Unit	Note
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 × 1 000 −0,5	N × 1 000	N × 1 000 +0,5	ms	N = 5,7 or 13[h]
FAC time out[e]	All	t_{TO}	25		30	s	

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

[a] Measured in centre of outer symbol (frequency vs. time eye opening) transmitting PN9 sequence, min./max. based on rms error value.

[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 Frequent Access Cycle (FAC). The reference time point shall be the end of the preamble (end of sync sequence) of the Meter transmission.

[d] The selected timeslot *N* shall be the same throughout the Frequent Access Cycle.

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

[f] If needed, a maximum of 8 symbols may be added for power ramping prior to the preamble.

[g] The extended delay enables the Other Device time to perform operations like cryptographic operations on dynamic data.

[h] It shall be ensured that the FAC transmission delay selected does not interfere with the response delay used.

10.3 Receiver sensitivity

The receiver sensitivity and blocking performance shall be as given in Table 23.

Table 23 — Mode N, Receiver

Characteristic	Class	Symbol	min.	typ.	max.	Unit	Note
Sensitivity (BER < 10^{-2}) or (PER < 0,8)[a], GFSK	H_R	P_o	−115	−123		dBm	2,4 kbps
Sensitivity (BER < 10^{-2}) or (PER < 0,8)[a], GFSK	H_R	P_o	−112	−120		dBm	4,8 kbps
Sensitivity (BER < 10^{-2}) or (PER < 0,8)[a], 4GFSK	H_R	P_o	−109	−112		dBm	6,4 kbps
Sensitivity (BER < 10^{-2}) or (PER < 0,8)[a], 4GFSK	H_R	P_o	−104	−107		dBm	19,2 kbps
Blocking Performance[b]	L_R		2[e]			Category	
Blocking Performance[b c]	M_R		2			Category	
Blocking Performance[b c d]	H_R		2			Category	

[a] At a frame size of 20 bytes.

[b] Receiver category according to ETSI EN 300 220–1, V3.1.1:2017, 4.2.5.

[c] Additional requirements for Class M_R and Class H_R receivers: The equipment shall meet the immunity requirements as specified in Draft ETSI EN 301 489–1, V2.2.0:2017, 9.2.

[d] Additional requirement for Class H_R receivers: Adjacent channel selectivity shall be > 40 dB when measured according to ETSI EN 300 220–1, V3.1.1:2017, 5.15.

[e] Blocking performance category 3 is no more sufficient.

10.4 Data encoding and preamble

10.4.1 Encoding

Data transmitted using GFSK modulation shall be NRZ encoded, with the low frequency corresponding to a binary “0”.

Data transmitted using 4GFSK modulation shall be NRZ encoded, with the lowest frequency corresponding to binary “01” (symbol A), the second frequency corresponding to binary “00” (B), the third frequency corresponding to binary “10” (C) and the highest frequency corresponding to binary “11” (D).

Each data byte shall be transmitted with the most significant bit first.

The order of multi byte fields is defined in 12.2.

10.4.2 Preamble and synchronization pattern

All transmissions using GFSK shall, where *n* = 8, be preceded by either;

— $n \times (01)\ 11110110\ 10001101_b$ (frame format A) or,

— $n \times (01)\ 11110110\ 01110010_b$, (frame format B).

All transmissions using 4GFSK shall, where n = 8, be preceded by either;

— n × (AD) DDDDADDA DAAADDAD$_b$ (frame format A) or,

— n × (AD) DDDDADDA ADDDAADA$_b$ (frame format B).

NOTE The first pattern is equivalent to, the bit pattern n × (0111) 1111111101111101 1101010111110111$_b$ and the second pattern is equivalent to the bit pattern n × (0111) 1111111101111101 0111111101011101$_b$.

All chips of each frame, including pre- and postamble, shall form an uninterrupted sequence.

The decoder may optionally detect that the receiver has captured another transmission, by detecting a new preamble and synchronization pattern 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 devices.

11 Mode F

11.1 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 band duty cycle are given in Table 24.

Table 24 — Mode F, Channel properties

Characteristic	min.	typ.	max.	Unit
Frequency band[a]	433,050	433,820	434,790	MHz
Transmitter duty cycle			10	%

[a] This European Standard is optimized for the 433 MHz band, although with an appropriate transmission licence, other frequency bands could be used.

11.2 Physical link parameters

The transmitter parameters shall be as given in Table 25.

Table 25 — Mode F, Transmitter parameters

Characteristic	Symbol	Mode	min	typ.	max	Unit	Note
Centre frequency		All	433,813	433,82	433,827	MHz	16 ppm
FSK Deviation[a]		F2, F2-m	±4,8	±5,5	±7,0	kHz	
Data rate		F2, F2-m		2,4		kcps	
Data rate tolerance		All			±100	ppm	
Response delay[b] (Meter to Other Device)	t_{RM}	F2-m	3	50	4 000	ms	
Fast response delay[c d] (O-2-M) (default)	t_{RO}	F2	99,5	100	100,5	ms	
Slow response delay[c d] (O-2-M)	t_{RO_slow}	F2	999,5	1 000	1 000,5	ms	
FAC transmission delay[e f]	t_{TxD}	F2	N × 1 000 −0,5	N × 1 000	N × 1 000 +0,5	ms	N = 5,7 or 13
FAC time out[g]	t_{TO}	F2	25		30	s	

a 75 % to 125 % of nominal deviation measured in centre of chip (frequency vs. time eye opening) transmitting a 9 bit pseudo-random (PN9) sequence, min./max. based on the root-mean-square (rms) error value selected.

b The time a Meter shall delay the response to a received message from an Other Device.

c 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.

d The use of slow or fast response delay is specified in the “Communication Control Field” of the Extended Link Layer – see 13.2.7.3. For timing diagrams see Annex E. If an Extended Link Layer is not included in the frame, the default response delay shall be used.

e 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 Frequent Access Cycle (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: This is the time period between the last successful reception of a frame from the Other Device during the Frequent Access Cycle (FAC) and the moment where the repetition of the last response of the Meter shall be stopped (end of Frequent Access Cycle).

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 Other Device shall be repeated with a delay less than 5 ms (t_{DRF}). For timing diagrams see Annex E.

11.3 Receiver sensitivity

The receiver sensitivity and blocking performance shall be as given in Table 26.

Table 26 — Mode F, Receiver

Characteristic	Class	Symbol	min.	typ.	max.	Unit	Note
Sensitivity (BER < 10^{-2}) or (PER < 0,8)[a]	H_R	P_o	−115	−117		dBm	2,4 kbps
Blocking performance[b]	L_R		2[e]			Category	
Blocking performance[b c]	M_R		2			Category	
Blocking performance[b c d]	H_R		2			Category	

a At a frame size of 20 bytes.

b Receiver category according to ETSI EN 300 220–1, V3.1.1:2017, 4.2.5.

c Additional requirements for Class M_R and Class H_R receivers: The equipment shall meet the immunity requirements as specified in Draft ETSI EN 301 489–1, V2.2.0:2017, 9.2.

d Additional requirement for Class H_R receivers: Adjacent channel selectivity shall be > 40 dB when measured according to ETSI EN 300 220–1, V3.1.1:2017, 5.15.

e Blocking performance category 3 is no more sufficient.

11.4 Data encoding and preamble

11.4.1 Data Encoding

Data transmitted using FSK modulation shall be NRZ-encoded. The low frequency shall correspond to a binary “0”. Each data byte shall be transmitted with the most significant bit first.

The order of multi byte fields is defined in12.2.

11.4.2 Preamble and synchronization pattern

All transmitted data shall be preceded by a preamble. It shall for Data Link Layer format A be; n × (01) $1111\ 0110\ 1000\ 1101_b$, with $n \geq 39$. It shall for Data Link Layer format B be; n × (01) $1111\ 0110\ 0111\ 0010_b$, with $n \geq 39$.

12 Data Link Layer

12.1 General

The Data Link Layer follows immediately after the preamble and synchronization pattern (Medium Access Layer). This standard supports the two different frame formats A and B for the Data Link Layer. The frame format shall be detected by the preamble and synchronization pattern (refer to the description of the respective modes). The frames are divided into blocks. In both formats, the first block has a fixed length of 10 bytes and contains the link layer, which consists of the frame length (L-field), the control information (C-field), and the sender address (Link Layer Address). The second block starts with the CI-field which is used to declare the structure of the following data. The following data consist of one or several layers before the application data (if any). This can be a collapsed Extended Data Link/Network Layer and an application data header referred to as the Transport Layer, a Network Layer (see EN 13757-5), or an extension to the link layer (Extended Link Layer), as described in the following. The CI-field also defines the application protocol (if any).

The availability of multiple frame formats does not imply that a Device, be it a Meter or an Other Device, shall concurrently support both frame formats. A Device may implement both frame formats. A Meter should, once installed not change its frame format.

For modes where both frame formats are supported, the Other Device should, while performing installation of a Meter, detect both frame formats. The Other Device could during subsequent communications synchronize only on the Meters known frame format.

12.2 Order of multi byte fields

Any byte sequence of multi byte fields, before the first CI-field, shall be transferred with the low byte first. The byte sequence of multi byte fields after CI-fields of 80_h, 82_h, 83_h, 86_h and 88_h to $8F_h$ (see 13.2 and 13.3) shall be as well transferred with the low byte first. The byte sequence of other multi byte fields is not defined in this document. Multi byte fields after the CI-field shall be transferred as specified in the implemented layers, i.e. according to EN 13757-1 and EN 13757-3 for the application layer and in EN 13757-7 for the transport layer.

The byte sequence of the CRC shall be transferred with the high byte first.

12.3 Frame format A

Frame format A complies to EN 60870-5-1 with the format Class FT3. The start bytes 05_h 64_h are replaced by the preamble chip sequence as described in the respective mode. The format of the different blocks in the frame is specified below.

The format of the first block shall be as shown in Table 27:

Table 27 — Format A, first block format

L-field	C-field	M-field	A-field	CRC-field
1 byte	1 byte	2 bytes	6 bytes	2 bytes

The format of the second block shall be as shown in Table 28:

Table 28 — Format A, second block format

CI-field	Data-field	CRC-field
1 byte	15 or if it is the last block (((L-9) modulo 16) −1) bytes	2 bytes

The format of any subsequent optional block shall be as shown in Table 29:

Table 29 — Format A, optional block(s) format

Data-field	CRC-field
16 or if it is the last block ((L-9) modulo 16) bytes	2 bytes

12.4 Frame format B

The link layer check of frame format B is performed on a maximum of 128 bytes including the CRC-field. Frames with a length of up to 128 bytes, including CRC- and L-field, contain a single CRC-field covering both first block and second block. Frames with a length between 131 bytes and 256 bytes (maximum length) contain two CRC-fields where the second CRC-field covers the optional block. The format of the different blocks in the frame is specified below.

The format of the first block shall be as shown in Table 30.

Table 30 — Format B, first block format

L-field	C-field	M-field	A-field
1 byte	1 byte	2 bytes	6 bytes

The format of the second block shall be as shown in Table 31.

Table 31 — Format B, second block format

CI-field	Data-field	CRC-field
1 byte	115 or if it is the last block (L-12) bytes	2 bytes

The format of any subsequent block shall be as shown in Table 32.

Table 32 — Format B, optional block format

Data-field	CRC-field
(L-129) bytes	2 bytes

12.5 Field definitions

12.5.1 General

The fields as defined in EN 60870-5-1 (L-field) and EN 60870-5-2 (C-field, M-field and A-field) are specified in the subsequent subclauses. The A-field of EN 60870-5-2 corresponds to the concatenation of the M-field and the A-field presented here.

12.5.2 Multi byte fields

Multi byte fields shall be handled as specified in 12.2.

12.5.3 Length field (L-Field)

Frame format A:

The first byte of the first block is the length field. The field specifies the number of subsequent user data bytes including the control and address bytes and excluding the CRC bytes. If ((L-9) MOD 16) is not zero, then the last block shall contain ((L-9) MOD 16) data bytes + 2 CRC bytes. All the other blocks except the first block shall always contain 16 data bytes + 2 CRC bytes.

Frame format B:

The first byte of the first block is the length field. The field specifies the number of all subsequent bytes including all CRC bytes.

12.5.4 Control field (C-Field)

The second byte of the first block is the C-field. It specifies the frame type.

The general format of the C-field, bit by bit is as shown in Table 33.

Table 33 — C-field data format

MSBit				LSBit	
RES	PRM	FCB	FCV	Function code	Primary to secondary
		ACD	DFC		Secondary to primary

RES – bit shall always be ‘0’.

PRM – ‘1’ message from primary (initiating) station;

‘0’ message from secondary (responding) station.

FCB, FCV and ACD, DFC-bit coding shall be used according to the rules in EN 60870-5-2.

The Function codes as given in Table 34 and Table 35 may be used. Primary station and secondary station are defined in EN 60870-5-2.

Table 34 — Function codes of the C-field in messages sent from primary stations

Func. code	Symbolic name	Direction	Function	Confirmation by	Support by meter
0_h	SND-NKE[a, b]	To meter	Link reset after communication; It clears the FCB and finishes the Frequent Access Cycle. It also signals an applicable radio link to a Meter which has sent an installation message (SND-NKE contains no application data).	—	Mandatory for S2, T2, C2, R2, N2 and F2
3_h	SND-UD/ SND-UD2[c]	To meter	Send a command (Send User Data)	ACK/NACK/ RSP-UD[c]	Mandatory for S2, T2, C2 and R2, N2 and F2
4_h	SND-NR[d,f]	From meter	Send unsolicited/periodical application data without request (Send/No Reply)	—	Mandatory for S1, T1, C1 and N1
5_h	SND-UD3[f,h]	To meter	Send a command to multiple receivers at the same time (Send User Data) No reply	—	Optional
6_h	SND-IR[f]	From meter	Send manually initiated installation data (Send Installation Request)	CNF-IR	Optional
7_h	ACC-NR[f]	From meter	Send unsolicited/periodical message to provide the opportunity of access to the Meter (contains no application data)	—	Optional
8_h	ACC-DMD[f]	From meter	Access demand from Meter to Other Device. This message requests an access to the Meter (contains no application data)	ACK	Optional
A_h	REQ-UD1[e,g]	To meter	Alarm request, (Request User Data Class 1) (contains no application data)	ACK/RSP-UD[e]	Mandatory for S2, T2, C2, R2, N2 and F2
B_h	REQ-UD2[g]	To meter	Data request (Request User Data Class 2) (contains no application data)	RSP-UD	Mandatory for S2, T2, C2, R2, N2 and F2

Func. code	Symbolic name	Direction	Function	Confirmation by	Support by meter

[a] After a FAC-Timeout happens (refer to 12.6.3.3) the FCB shall be cleared automatically.

[b] Named SND-NKE in EN 13757-2.

[c] The SND-UD is used together with a valid FCB (C-field is 53_h or 73_h) and shall be responded with an ACK message. If the meter receives Function code 3_h with a cleared FCV-bit (C-field is 43_h), the meter shall assume the reception of an SND-UD with a subsequent REQ-UD2. Therefore it shall respond with the corresponding RSP-UD instead of an ACK. This message is called SND-UD2. The support of the SND-UD2 is optional. If the meter does not support the message SND-UD2, it shall respond with a NACK and discard the message. Note that legacy meters implemented according to EN 13757-4:2013 or previous versions of this standard will respond with an ACK. The SND-UD2 is not applicable for fragmented messages. See also Annex E.

[d] The meter may use a Frequent Access Cycle (FAC), i.e. retransmitting the same message a limited number of times, until the Other Device responds. The Other Device should use SND-NKE to respond and the meter should then finish the FAC.

[e] If the meter has no support for alarm data, it has at least to respond with an ACK.

[f] This message type shall be used with FCV = 0.

[g] This message type shall be used with FCV = 1.

[h] The SND-UD3 should be applied for multi or broadcast transmissions; see also EN 13757–3:2018, Annex I.

Table 35 — Function codes of C-field in messages sent from secondary stations

Func. code	Symbolic name	Direction	Function	Initiated by	Support by meter
0_h	ACK	Both directions	Acknowledge the reception of an ACC-DMD or SND-UD (acknowledgement of transmission only). It shall as well be used as a response to an REQ-UD1 when no alert happened (contains no application data).	SND-UD/ ACC-DMD	Mandatory for S2, T2, C2, R2, N2 and F2
1_h	NACK [a]	From meter	Replace an ACK in the case of: — Meter reception buffer overflow — Datagram with invalid or unknown C-field	SND-UD/ SND-UD2	Optional
6_h	CNF-IR	To meter	Confirms the successful registration (installation) of meter to service tool (contains no application data).	SND-IR	Optional
8_h	RSP-UD	From meter	Response of application data after a request from the primary station (response of user data)	REQ-UD1/ REQ-UD2/ SND-UD2	Mandatory for S2, T2, C2, R2, N2 and F2

[a] A NACK-frame uses the same frame structure as an ACK-frame, the only difference being the C-field.

12.5.5 Manufacturer ID (M-field)

The third and the fourth byte of the first block shall contain a unique User/Manufacturer ID of the sender. The 15 least significant bits of these two bytes shall be formed from a three letter ISO/IEC 646 code (A … Z) as specified in EN 13757-7:2018, 7.5.2.

If the most significant bit of these two bytes User/Manufacturer ID is equal to zero, then the address A shall be a unique (hard coded) manufacturer meter address of 6 bytes. Each manufacturer is responsible for the worldwide uniqueness of these 6 bytes. Any type of coding or numbering, including type/version/date may be used as long as the ID is unique.

If the most significant bit of this two-byte User/Manufacturer ID is different from zero, then the 6 byte address shall be unique at least within the maximum transmission range of the system (soft address). This address is usually assigned to the device at installation time. As long as these unique address requirements are fulfilled, the remaining bytes may be used for user specific purposes.

NOTE The address is used in the back office to identify the meter independently of its communication interface. Therefore the manufacturer needs to ensure a uniqueness of the addresses not only for wireless meters but for all produced meters.

12.5.6 Address (A-field)

This address field A contains, in deviation to EN 60870-5-2, always the address of the sender. At uplink – the address of a Meter with integrated radio module or the address of a radio adapter supporting a Meter without a radio module and at downlink the address of the Other Device. The address of the receiver (required for the downlink) shall follow in the Extended Data Link Layer, see 13.2, or in the Transport Layer, see 13.3. The address shall be unique, see 12.5.5. Each User/Manufacturer shall guarantee that this address is unique. If this protocol is used together with the Transport Layer or the Application Layer of EN 13757-3 then the following Address structure shall be applied: the A-field shall be generated as a concatenation of the 'Identification number', 'Version number' and 'Device type information' as specified in EN 13757-7:2018, 7.5.1, 7.5.3 and 7.5.4, refer to examples in Annex C.

NOTE If the meter address differs from the sender address, the meter address will be transmitted after the CI-field using a long Transport Layer; see 13.3.3 and EN 13757-7.

12.5.7 Cyclic redundancy check (CRC-field)

The CRC shall be computed over the information from the previous block, and shall be generated according to FT3 of EN 60870-5-1. The formula is:

The CRC polynomial is: $x^{16} + x^{13} + x^{12} + x^{11} + x^{10} + x^{8} + x^{6} + x^{5} + x^{2} + 1$

The initial value is 0.

The final CRC is complemented.

12.5.8 Control information field (CI-field)

The first byte of the second block is the CI-field. The CI-field specifies the type of protocol and thus the nature of the information that follows. The CI-field may declare an Application Layer, an Authentication and Fragmentation Layer, a Transport Layer, a Network Layer or an Extended Link Layer. The CI-field is defined in 13.1.

12.6 Timing

12.6.1 Timing for installation messages

A Meter may support additional installation messages. The installation messages shall be started only with a manual event (e.g. by pressing a button). The transmission of installation messages shall start immediately after this event.

For an efficient commissioning the installation messages (SND-IR) shall be repeated at least 6 times with an interval of 30 s to 60 s. The transmission of installation messages shall stop no later than 60 min after the manual start event.

If the Other Device receives an installation message (SND-IR) and registers this Meter finally for permanent reception, it should respond with a Confirm Installation Message (CNF-IR) to signal the successful registration to the Meter itself and to an optionally service tool. If the Meter receives this message, it may stop the repetition of installation messages. The service tool may use this message to give a feedback to the service technician, about the successful meter installation.

If the Other Device receives an installation message (SND-IR) it may generate a feedback message (SND-NKE) to a service tool. To avoid collisions with a second Other Device the transmission of the feedback message (SND-NKE) shall be randomly delayed between 5 s and 25 s after the reception of the Meter installation message. The transmission of the feedback message (SND-NKE) is independent from the transmission or reception of a Confirm Installation Message (CNF-IR). Refer to CEN/TR 17167:2018 Annex D.

12.6.2 Synchronous transmissions of meter messages

In order to enable battery efficient Other Device's (data concentrators, repeaters, etc.) that only switch on their receivers for predicted short time windows, the Meter should follow a strict transmission time scheme. The use of the synchronous transmission scheme is optional.

The Meter shall transmit synchronous messages at least with a nominal (i.e. average) transmission interval given by Table 36.

The synchronous messages shall be of the type SND-NR, ACC-DMD or ACC-NR (C-fields 44_h, 48_h or 47_h). They shall contain a short or long header or a CI-field in the range 86_h or $8C_h$ to $8F_h$ (Table 42) because the access number is required. ACC-NR messages may be used just to maintain synchronization. SND-NR, ACC-DMD and ACC-NR messages may be mixed.

Table 36 — Maximum values of nominal transmission interval, t_{NOM}

Mode	t_{NOM} (max)
T, C	15 min
S	120 min
R, N, F	24 h

The synchronous messages shall be transmitted at individual transmission intervals (measured from start of message to start of the next message) given by:

$$t_{ACC} = (1 + (|n_{ACC} - 128| - 64) \;/\; 2048) \times t_{NOM}$$

$$t_{NOM} = n \times 2\ s$$

where

t_{ACC} is the individual transmission interval from the message with the access number n_{ACC} to the next message;

n_{ACC} is the value of the access number (from 0 to 255);

t_{NOM} is the fixed nominal transmission interval within the range specified in Table 26;

n is a fixed positive integer.

The access number n_{ACC} is given by:

— EN 13757-7:2018, 7.5.5,

The total allowed absolute tolerance of the fixed nominal transmission interval, t_{NOM}, consists of a static part and a dynamic part. The static part relates to initial component tolerances and slowly changing ageing effects and the dynamic part relates to faster changing dynamic effects such as temperature.

The static tolerance shall not evolve more than ± 1 ppm per day and shall be within:

— ± 40 ppm for all meters.

The additional dynamic tolerance shall be within:

— +90/−10 ppm for meters operating in the temperature range −15 °C to +65 °C,

— +210/−10 ppm for all other meters.

The total allowed absolute tolerance over device life time and over all temperatures shall thus be:

— +130/−50 ppm for meters operating in the temperature range −15 °C to +65 °C,

— +250/−50 ppm for all other meters.

A non-accumulative jitter on the nominal transmission interval due to discrete time quantization is allowed. It shall for:

— t_{NOM} < 300 s be less than ± 1 ms,

— t_{NOM} ≥ 300 s be less than ± 3 ms.

For messages with a CI-field that deviates from 86_h and $8C_h$ to $8F_h$, all synchronous messages shall be marked as such by setting the sync-bit in the Configuration field of the Transport Layer. For the Configuration field refer to EN 13757-7:2018, 7.7.2 and 7.7.4.

For messages with a CI-field of 86_h or $8C_h$ to $8F_h$, all synchronous messages shall be marked as such by setting the Synchronized Subfield in the Communication Control Field. For the Communication Control Field refer to 13.2.7.4.

Additional non-synchronous messages may be transmitted, according to the timing rules of this standard, e.g. in bidirectional communication. The non-synchronous messages shall be marked as such by a cleared sync-bit respectively Synchronized Subfield.

Meters using the mode S1 and mode S2 shall always transmit synchronous messages using the long preamble to support a battery efficient communication partner.

The meter manufacturers are strongly recommended to initialize the access numbers and internal transmission timers of different meters with widely distributed random values to avoid systematic collisions.

The meter may omit single synchronous transmissions if a task of higher priority (e.g. a metrological algorithm that cannot be postponed) needs to be performed at the scheduled transmission point in time. The rate of omitted synchronous messages shall not exceed 6,25 % per sliding 24 h time period. The access number, n_{ACC}, shall be incremented as if all synchronous transmissions had been executed.

Annex D shows an example for the prediction of a synchronous transmission time.

12.6.3 Access timing

12.6.3.1 General

This subclause describes the timing which the Other Device communication has to consider for a successful access to a Meter.

12.6.3.2 Mode R, S, T, C, N and F: Access to meter

For mode R, S, T, C, N, and F the Other Device can access the R2, S2, T2, C2, F2 or N2 Meter only if the meter is ready to receive.

The R-, S-, T-, C-, N- and F-Meter signals, for every transmission, its own accessibility in either the Configuration Field of the Transport Layer, see Configuration Field in EN 13757-7:2018, 7.7.2 and 7.7.4, or in the Communication Control Field of the extended Link Layer, see 13.2.7. The Other Device shall, before it transmits a message to the Meter, check the accessibility of the meter in the previously received frame from the Meter. See Table 37.

Table 37 — Accessibility of an R-, S-, T-, C-, N-, F-meter

Bit B[a]	Bit A[b]	Accessibility of the meter
0	0	No access - Meter provides no access windows (unidirectional meter)
0	1	Temporary no access – Meter supports bidirectional access in general, but there is no access window after this transmission (e.g. temporary no access in order to keep duty cycle limits or to limit energy consumption)
1	0	Limited access - Meter provides a short access windows only immediately after this transmission (e.g. battery operated meter)
1	1	Unlimited access – Meter provides unlimited access at least until next transmission (e.g. mains powered devices)

[a] Bit B refers to either Bit 15 in the Configuration Field, see EN 13757-7:2018, 7.7.2 and 7.7.4, or to Bit 7 in the Communication Control Field, see 13.2.7.2.

[b] Bit A refers to either Bit 14 in the Configuration Field, see EN 13757-7:2018, 7.7.2 and 7.7.4, or to Bit 2 in the Communication Control Field, see 13.2.7.7.

Examples of this are;

No access – Unidirectional meters (modes S1, T1, C1 or N1) are never accessible.

Temporary no access – If a bidirectional meter is not ready to respond by the reason of energy limitation, duty cycle or other reasons then it shall declare “temporary no access”.

Limited access – Battery operated meters are often very restricted in their energy consumption. They will provide a short access window only immediately after the transmission. The Other Device (as master) may initiate a communication to the Meter (as a slave) during this timeslot. The beginnings and the end of the timeslot are given as response delay t_{RO} in Table 5, Table 8, Table 12, Table 15, Table 22 and Table 25.

Unlimited access – Mains powered Meters have typically sufficient energy to keep the receiver ready to receive all the time. Therefore the Other Device may send a command or a request at any time. It is limited by duty cycle requirements only. Even battery powered devices may signal temporary unlimited access as long as the receiver is continuously ready to receive.

12.6.3.3 Frequent Access Cycle

The Other Device may send/request several messages to/from the Meter. If one message of the message sequence is corrupted, the communication will be interrupted. The Other Device has to wait until the next regular transmission of the Meter to continue the sequence. The data exchange will be more reliable if the bidirectional meter supports the optional Frequent Access Cycle.

If a Meter receives a command or request to its address, it switches to the Frequent Access Cycle. During the Frequent Access Cycle, the Meter shall repeat the last message periodically with a FAC-Transmission delay t_{TxD} until the next request/command is received. This offers the Other Device a fast access to the meter even in case of a lost message. The Frequent Access Cycle lasts until the FAC-Timeout t_{TO} after the last successful reception of a command or a request from the same communication partner (Other Device). The Other Device can stop the Frequent Access Cycle of the Meter earlier by sending a SND-NKE-message to the meter at the end of the communication. The timing of the Frequent Access Cycle is shown in Annex E.

NOTE The Transmission delay t_{TxD} considers the case of an additional radio network between the Other Device and the Meter itself. Such a network delays the Meter message as well as the next request of the Other Device. It is also noted that many readout sessions may be performed in parallel in a short time period. To avoid collisions of meter messages with those of other meters, an off-time between the transmissions needs to be considered.

12.7 Repeated or duplicate messages

The use of simple repeaters may cause the reception of duplicate messages. Messages from a repeater are tagged by the Hop Count-bit, and depending on the type of repetition as well by the Repeated Access-bit. These bits are located in the Extended Link Layer or the Transport Layer Configuration Field. Refer to EN 13757-5 for details. Meters, in particular those with permanent receivers and Other Devices, shall be able to identify and discard duplicate messages.

12.8 Forward Error Correction (FEC)

12.8.1 Overview

The Data Link Layer provides an optional Forward Error Correction (FEC) capability by adding redundant data to the datagram. This allows to correct a certain number of bit errors that may have occurred to the datagram during the transmission.

The FEC can be used to improve the reliability of the transmission of large amounts of data, e.g. for software upload, or to enhance the radio link budget.

12.8.2 Datagram structure

12.8.2.1 General

The optional FEC data are inserted between the datagram frame including CRC, be it format A or format B, and the mode specific postamble, see Table 38.

Table 38 — Datagram structure with FEC

Preamble and synch pattern	Frame (format A or B) including CRC	FEC data (optional)		Postamble
		FEC header	FEC check data	

The FEC data are located directly after the last byte of the frame the length of which is specified by the L field. There is no indication within the frame whether FEC is included or not.

The use of FEC may conflict with repeating of frames.

12.8.2.2 FEC header

The FEC header is a 16 bit field. It holds a triplicate 5 bit FEC ID. Triplication makes it possible to perform error correction on the FEC ID using bitwise majority decision. Table 39 outlines the bit allocation in the FEC header. Bit 15 shall be transmitted as 0 and be a don't care read bit. The FEC header shall be transmitted with LSB first.

Table 39— FEC header structure

Bit 15	Bit 14 – 10	Bit 9 – 5	Bit 4 – 0
RFU(0)	FEC ID	FEC ID	FEC ID

The FEC ID is allocated as shown in Table 40.

Table 40 — FEC ID allocation

FEC ID	Algorithm	FEC header value
00_h	Reserved for future functions	0000_h
01_h	Reed Solomon (255, 223)	0421_h
02_h – 17_h	Reserved for future algorithms	
18_h – $1E_h$	Manufacturer specific algorithms	
$1F_h$	Reserved for future algorithms	$7FFF_h$

12.8.2.3 FEC check data

The FEC redundancy data follows the FEC header. The size of the check data will depend on the algorithm used.

12.8.3 FEC Algorithm

12.8.3.1 General

The algorithm used is specified in the FEC ID.

12.8.3.2 Reed Solomon (255,223)

The Reed Solomon coding shall have a block size of 255 symbols. The symbol size, J, is 8 bit i.e. a byte.

The Reed Solomon code shall have a correction capability, E, of 16 symbols. This implies that there are 223 bytes of information in a block. Information block of less than 223 bytes shall be padded to a full code block before correction bytes are calculated. The padding bytes shall be 00_h. The sender shall omit sending the padding bytes as the actual size of data can be determined by the length field of the frame.

The field generator polynomial shall be as specified in CCSDS 131.0-B-2, August 2011, section 4.3.3.

The code generator polynomial shall be as specified in CCSDS 131.0-B-2, August 2011, section 4.3.4.

The applicability of Reed Solomon based FEC for the different modes is shown in Table 41.

Table 41 — Possible use of FEC for different modes

Mode	Unidirectional	Bidirectional
S	Yes	No
T	Yes	No
R	No	No
C	Yes	Yes
N	Yes	Yes
F	Yes	No

13 Connection to higher protocol layers

13.1 The Control Information Field (CI-field)

The CI-field specifies the structure of the next higher protocol layer. The first byte after the Data Link Layer is this CI-field. The remainder of the message depends on the selected layer and the application protocol used.

For the transport of the Application Layer information by this wireless communication standard the Transport Layer with short or long header should be used. Both Transport Layers always contains an access number and the Configuration Field. As an alternative, the Extended Link Layer may be applied.

The value of the CI-field shall be used as specified in Table 42 and EN 13757-7:2018, Table 2.

Table 42 — CI-field

CI-value	Designation	TPL-Header	Remarks
80_h	Transport Layer to device (without APL)	Long	For support of EN 13757-3 Transport Layer without Application Layer (e.g. REQ-UD2); (see 13.3)
82_h	Network management data to device	Short	For support of Network management commands (see Clause 14) (Further Network management commands are defined in EN 13757-5)
83_h	Network management data to device	None	For support of Network management commands (see Clause 14) (Further Network management commands are defined in EN 13757-5)
86_h	Extended Link Layer V (variable length)	—	Additional Link Layer may be applied for Radio messages with or without Application Layer Support of selectable service (see 13.2)
87_h	Network management data from device	Long	For support of Network management responses (see Clause 14) (Further Network management responses are defined in EN 13757-5)
88_h	Network management data from device	Short	For support of Network management responses (see Clause 14) (Further Network management responses are defined in EN 13757-5)

CI-value	Designation	TPL-Header	Remarks
89_h	Network management data from device	None	For support of Network management responses (see Clause 14) (Further Network management responses are defined in EN 13757-5)
$8A_h$	Transport Layer from device (without APL)	Short	For support of EN 13757-3 Transport Layer without Application Layer (e.g. ACK); (see 13.3)
$8B_h$	Transport Layer from device (without APL)	Long	For support of EN 13757-3 Transport Layer without Application Layer (e.g. ACK); (see 13.3)
$8C_h$	Extended Link Layer I (2 Byte)	—	Additional Link Layer may be applied for Radio messages with or without Application Layer (see 13.2)
$8D_h$	Extended Link Layer II (8 Byte)	—	Additional Link Layer may be applied for Radio messages with or without Application Layer (see 13.2)
$8E_h$	Extended Link Layer III (10 Byte)	—	Additional Link Layer may be applied for Radio messages with or without Application Layer (see 13.2)
$8F_h$	Extended Link Layer IV (16 Byte)	—	Additional Link Layer may be applied for Radio messages with or without Application Layer (see 13.2)
92_h – 97_h	Reserved	—	
This table is an extension of EN 13757-7:2018, Table 2. It contains CI-values especially defined for wireless communication. CI-values provided in EN 13757-7:2018, Table 2 may be also applied together with this standard. NOTE The term “device” corresponds to “meter device”.			

13.2 CI-fields for the Extended Link Layer

13.2.1 General

The Extended Link Layer provides additional control fields especially for wireless communication. Additional layers as listed in Table 42 (excluding the CI-fields 86_h and $8C_h$ to $8F_h$) may follow after the Extended Link Layer.

In the case of an Extended Link Layer, the CI-field specifies the length and the structure of the extension. Each type of Extended Link Layer provides different services.

Multi byte fields shall be transmitted with low byte first. The length and structure of the Extended Link Layer is illustrated in Table 43 below.

Table 43 — CI-fields for the Extended Link Layer

CI-value	Length Extended Link Layer	Structure Extended Link Layer	Service
86_h	3 to 20 bytes	CC, ACC, variable fields (see Table 48)	Selectable Services (see Table 49)
$8C_h$	2 bytes	CC, ACC	Communication Control, Synchronization
$8D_h$	8 bytes	CC, ACC, SN, PayloadCRC	Communication Control, Synchronization, Encryption
$8E_h$	10 bytes	CC, ACC, M2, A2	Communication Control, Synchronization, Destination Address
$8F_h$	16 bytes	CC, ACC, M2, A2, SN, PayloadCRC	Communication Control, Synchronization, Destination Address, Encryption

Examples of the different structures of the extension block are shown in the sections that follow.

13.2.2 CI-field = $8C_h$

This value of the CI-field is used if data encryption at the link layer is not used in the frame. Table 44 below, shows the complete extension block in this case.

Table 44 — Extended Link Layer with CI = $8C_h$

CI-field	CC-field	ACC-field
$8C_h$	1 byte	1 byte

13.2.3 CI-field = $8D_h$

This value of the CI-field is used if data encryption at the link layer is used in the frame. Table 45 below, shows the complete extension block in this case.

Table 45 — Extended Link Layer with CI = $8D_h$

CI-field	CC-field	ACC-field	SN-field	Payload CRC-field
$8D_h$	1 byte	1 byte	4 bytes	2 bytes

13.2.4 CI-field = $8E_h$

This value of the CI-field is used if data encryption at the link layer is not used in the frame. This extended link layer specifies the receiver address. Table 46 below shows the complete extension block in this case.

Table 46 — Extended Link Layer with CI = $8E_h$

CI-field	CC-field	ACC-field	M2-field	A2-field
$8E_h$	1 byte	1 byte	2 bytes	6 bytes

13.2.5 CI-field = $8F_h$

This value of the CI-field is used if data encryption at the link layer is used in the frame. This extended link layer specifies the receiver address. Table 47 below shows the complete extension block in this case.

Table 47 — Extended Link Layer with CI = $8F_h$

CI-field	CC-field	ACC-field	M2-field	A2-field	SN-field	Payload CRC-field
$8F_h$	1 byte	1 byte	2 bytes	6 bytes	4 bytes	2 bytes

13.2.6 CI-field = 86_h

The variable Extended Link Layer allows to select optional ELL fields separately. The shadowed rows of Table 48 shall always be present. The other fields are optional and can be selected in case they are needed. The table defines the ordering of the fields.

Table 48 — Extended Link Layer with CI field 86_h

Size (bytes)	Field Name	Description
1	CI	Indicates that an variable Extended Link Layer follows [a]
1	CC	Communication Control field[a]
1	ACC	Access number[a]
1	ECL	Extended Link Layer Control field, always present (see Table 36)[a]
2	M2	Manufacturer 2 field[b]
6	A2	Address 2 field[b]
4	SN	Session Number field[b]
2	RTD	Run Time Delay[b]
1	RXL	Reception Level[b]
2	PayloadCRC	Payload Checksum field[b]

a Always present.

b Present only, if enabled in ECL (see Table 49).

Table 49 defines the ECL-field

Table 49 — Extended Link Layer Control, ECL, field (1 byte)

Bit	Name	Description
7	PLP[a]	Payload Checksum field present in ELL
6	—	Reserved for future usage (0_b by default)
5	—	Reserved for future usage (0_b by default)
4	RXLP[a]	Reception Level present

Bit	Name	Description
3	RTDP	00_b – Frame Run Time Delay not present
		01_b – Frame Run Time Delay present, resolution 1/256 s
2		10_b – Frame Run Time Delay present with resolution 2 s
		11_b – Reserved for future usage
1	SNP[a]	SN field present in ELL
0	MAP[a]	M2 field and A2 field present in ELL
[a] 0_b = field is not present; 1_b = field is present		

13.2.7 Communication Control Field (CC-field)

13.2.7.1 General

This field, as shown in Table 50 is a combination of the Bi-directional subfield, the Response Delay subfield, the synchronized Subfield, the Hop Count subfield, the Priority subfield, the Accessibility subfield, the Repeated Access subfield and the Extended Delay subfield.

Table 50 — Communication Control Field

B-field	D-field	S-field	H-field	P-field	A-field	R-field	X-field
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0

13.2.7.2 Bi-directional Subfield (B-field)

Bit 7 of the Communication Control Field is the Bi-directional subfield. The use of this bit is identical to the Bit B in Table 37.

13.2.7.3 Response Delay Subfield (D-field)

But 6 of the Communication Control Field is the Response Delay subfield. It does, together with Extended Delay subfield define the way the responding unit shall respond. The coding is as shown in Table 51.

Table 51 — Response Delay Specification

D-field (bit 6)	X-field (bit 0)	Mode	Delay to use
0	0	Any	Slow delay
1	0	Any	Fast delay
0	1	R,S,T,C,F	RFU
		N	Extended delay
1	1	Any	RFU

A Meter shall return the setting from a received frame in the next frame from the Meter to the Other Device. This enables the Other Device to control the speed of the communication and thereby the channel occupation. It is, in fixed networks without the requirement for a fast response time, recommended always to use a setting of D = 0 in frames from the Other Device to the Meter. It is, in all other networks, recommended always to use D = 1 whenever possible. For timing diagrams, see Annex E.

13.2.7.4 Synchronized Subfield (S-field)

Bit 5 of the Communication Control Field is the Synchronized subfield. S = 1 indicates that this frame is synchronized as specified in12.6.2.

13.2.7.5 Hop Count Subfield (H-field)

Bit 4 of the Communication Control Field is the Hop Count subfield. If H = 0, the direct source of the frame is a Meter or an Other Device. If H = 1, the frame has been relayed by a repeater. This field is reserved for use in repeated messages; see EN 13757-5. A Meter shall always transmit with H = 0.

13.2.7.6 Priority Subfield (P-field)

Bit 3 of the Communication Control Field is the Priority subfield. If *P* = 0, the frame contains data that is to be treated in a normal manner. *P* = 1 indicates that the frame is prioritized, i.e. the data shall be transported as fast as possible, and if necessary, delaying other frames in the system. Only frames containing alarms and other non-frequent data shall utilize this bit.

13.2.7.7 Accessibility Subfield (A-field)

Bit 2 of the Communication Control Field is the Accessibility Subfield. The use of this bit is identical to the Bit A in Table 37.

13.2.7.8 Repeated Access Subfield (R-field)

Bit 1 of the Communication Control Field is the Repeated Access subfield. This field is reserved for use in repeated messages; see EN 13757-5. A Meter shall always set R = 0 and may ignore this bit when received.

13.2.7.9 Extended Delay Subfield (X-field)

Bit 0 of the Communication Control Field is the Extended Delay subfield. It defines together with the Response Delay subfield the timing to be used by a responding unit. See 13.2.7.3 for the combined function.

NOTE This field was ‘Reserved for Future Use’ in the previous version of this standard. The way it is implemented is backward compatible.

13.2.8 Access Number Field (ACC-field)

This field is the Access Number Field. The Access Number is used to identify and synchronize the transmissions from a Meter, see 12.6.2. For further specification, refer to EN 13757-7.

13.2.9 Manufacturer ID 2 (M2-field)

This field M2 shall contain a unique User/Manufacturer ID of the destination for this frame. The formatting of the M2 field shall be as for the M field specified in 12.5.5 The M2-field and the A2-field shall together generate a unique address.

13.2.10 Address 2 (A2-field)

This field A2 shall, together with the M2 field, contain a unique Address of the destination for this frame. The formatting of the A2 field shall be as for the A field specified in 12.5.6.

13.2.11 Session Number Field (SN-field)

13.2.11.1 General

This field, see Table 52, is a combination of the Encryption subfield, the Time-subfield and the Session subfield. The session number specifies the actual bidirectional communication session with a Meter. The session number is specified by the Meter in the initial transmitted frames, i.e. “SND-NR” or “ACC-NR” frames. During a bidirectional communication session with the Meter, the session number is unchanged. The Session Number Field value shall at least be changed after every bidirectional communication session with the Meter. This ensures that every bidirectional communication session with a Meter uses a unique Session Number field value.

The use of a session number that is never reused during the lifetime of the meter gives the possibility to use optimized encryption modes like the AES-128 Counter Mode Encryption.

Table 52 — Session Number Field

ENC-field	Time-field	Session-field
Bit 31 – Bit 29	Bit 28 – Bit 4	Bit 3 – Bit 0

13.2.11.2 ENC-subfield

Bit 31 to Bit 29 of this field is the Encryption Subfield. This specifies the encryption algorithm used, if any, as given in Table 53.

Table 53 — Encryption

XXX_b	Encryption selection
000_b	No encryption
001_b	AES-128 Counter Mode[a]
010_b to 111_b	Reserved for future use
[a] See 13.2.12	

NOTE When Link Layer Encryption is used, the frame needs to be decrypted before it is passed to the upper layers.

13.2.11.3 Time-subfield

Bit 28 to Bit 4 of this field describes the time of the meter. The Time-field describes a relative minute counter of the meter. Maximum time representation is approximately 64 years.

13.2.11.4 Session-subfield

Bit 3 to Bit 0 of this field describes the session within the minute specified by the Time-field. Within the same minute a maximum of 16 bidirectional communication sessions are possible. The first bidirectional communication session in every minute uses session = 0.

13.2.11.5 Specification of a session

In every transmission initiated by the Meter, i.e. “SND-NR” or “ACC-NR”, the Meter specifies a new Session Number Field. The actual value of the Session Number Field identifies the time of the Meter counted in minutes and the actual session within this minute. If the Other Device responds to this frame, a bidirectional communication session with the actual session number is established. Within this bidirectional communication session, the Session Number Field is unchanged.

The Session Number Field in frames from Other Device to Meter shall always be identical to the initial Session Number Field of the session defined by the Meter.

If the payload in the frame is unchanged since the last transmission from the Meter the Session Number field value can be reused. The Session Number field value shall at least be renewed every 300 s.

13.2.12 AES-128 Counter Mode Encryption

13.2.12.1 General

If the Encryption Subfield is ENC = 001_b, a standard AES-128 encryption in counter mode (CTR) shall be used.

NOTE For more information, see ISO/IEC 18033-3, NIST SP 800-38A and Annex F.

The counter mode encryption does not require the length of the encrypted data to be a multiple of 16 bytes resulting in that no extra padding bytes need to be added to the end of the frame.

The encryption covers all fields from and including the Payload CRC-field of the Extended Link Layer to the rest of the frame (not including the CRC-fields of the link layer). The AES-128 counter mode Initial Counter Block consists of 16 bytes as specified below. The Initial Counter Block (see Table 54) is made in a way that the value of the Initial Counter Block is unique for every encrypted block during the lifetime of the meter.

Table 54 — AES-128 (CTR) Initial Counter Block

M-field	A-field	CC-field	SN-field	FN	BC
2 bytes	6 bytes	1 byte	4 bytes	2 bytes	1 byte

13.2.12.2 Manufacturer ID field (M-field)

The value is retrieved from the first block of the Data Link Layer, see 12.5.5.

13.2.12.3 Address field (A-field)

The value is retrieved from the first block of the Data Link Layer, see 12.5.6.

NOTE The M-field and A-field contains the address of the sender and differs between up and downlink messages.

13.2.12.4 Communication Control Field (CC-field)

The value is retrieved from the Extended Link Layer, see 13.2.7. The bits of the Communication Control Field handled by the repeater (R-field and H-field) are always set to zero in the Initial Counter Block.

13.2.12.5 Session Number Field (SN-field)

The value is retrieved from the Extended Link Layer, see 13.2.11.

13.2.12.6 Frame Number (FN)

This field represents the Frame Number within the actual session. A new session number resets the Frame Number. The Frame Number shall count up for every frame in the current session. The first frame from the Meter to the Other Device initiated by the meter is always sent with FN = 0. In case of retransmission of a frame during the Frequent Access Cycle, see 12.6.3.3. The Frame Number is unchanged. For examples on the use of frame counter, see Annex D.

13.2.12.7 Block Counter (BC)

The Block Counter represents the encryption block number within the frame. The Block Counter shall be BC = 0 for the first encrypted block in each frame, and increments for each encrypted block in the frame.

13.2.13 Run Time Delay field (RTD-field)

Frames which require a clear reference to the transmission time point uses this optional field to cumulate the delay in each retransmission unit. The RTD-field is a 2 byte field which contains an unsigned integer word.

The content of this word depends on selected resolution. If resolution “2 seconds” selected, the value need to be multiplied with 2 to get the run time delay of the frame in seconds. If the resolution “1/256” seconds selected, the value need to be multiplied with 3,906 25 to get the run time delay of the frame in milliseconds.

At the time of first transmission the value shall be set to 0. Each retransmission unit shall add the rounded delay. This is the delay from reception of the last symbol of the synch word to the transmission of the last symbol of the synch word in the retransmitted datagram. In case the selected resolution wrap over the retransmission unit shall save the maximum value ($FFFF_h$). Alternatively it may select the next higher resolution for the run time delay. The CRC protecting the datagram shall be recalculated and updated when the RTD field is updated.

The RTD-field is not by default protected by a specific integrity check. This shall be taken into account when requiring a secure system. A calculation of the real measurement time solely based on the time stamp of the receiver and this run time delay is not recommended.

13.2.14 Reception Level field (RXL-field)

For the rating of link quality and for an adaptive power control is the reception level of the communication partner necessary. The RXL-field allows provide the reception level as RSSI or Link margin. The type is defined according to Table 55 below. The field is only useful for bidirectional communication. The field is a combination of the Signal Level Information subfield, the Reception Level Type subfield and the Reception Level subfield.

Table 55 — Meaning of the RXL-field

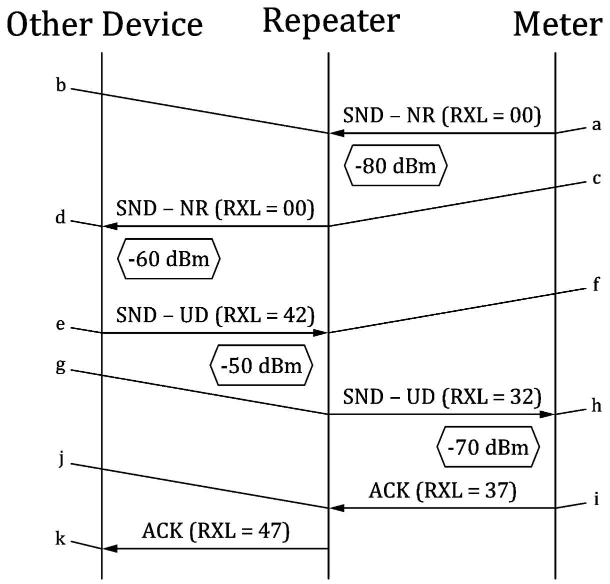
Name	Bit no.	Value and Meaning
	7	1: This content of the RXL-field is reserved for future use 0: The RXL-field contains signal level information as specified in the bits that follows
	6	0: The content represents the last received RSSI value for a reception from the communication partner 1: The content represents the link margin for the last reception from the communication partner
RL	5..0	0..63: Unsigned integer. The figure for the reception level, to be handled as shown in Table 56

Table 56 — Coding of reception level (RL) in RXL-field

Type	Value and Meaning
RSSI	0: No RSSI information available or wired communication 1: The RSSI −142 dBm or below 2..62: The RSSI is calculated as −144 + (2 × RL) dBm The RSSI is in the range −140 dBm to −20 dBm 63: The RSSI is −18dBm or above
Link Margin	0: No link margin information available or wired communication 1: The link margin is −10 dB or below 2..62: The link margin is calculated as (−11 +RL) dB The link margin is in the range −9 dB to +51 dB 63: The link margin is +52 dB or above

A value of 00000_b in bits 0 ... 5 indicates that either the transmitting device does not support reporting RSSI or link margin information or that the transmitting device has not received any frames within the current bi-directional session.

The RXL information is always related to the direct link between the device transmitting the information and the device receiving the information. A gateway receiving a message from a meter via a repeater will receive RXL information regarding the direct link between the repeater and the gateway. This RXL information is the reception level of frames from the gateway detected by the repeater. See example in Figure 1.



Key

a “Meter” send a message. RXL = 00 indicates no RSSI information included.

b “Repeater” receives at a RSSI of −80 dBm.

c “Repeater” retransmits to “Other Device”. RXL = 00 indicates no RSSI information.

d “Other Device” receives at a RSSI of −60 dBm.

e “Other Device” responds indicating a RL value at (d) of (144 − 60)/2, i.e. RXL = 42.

f “Repeater” receives at an RSSI of −50 dBm.

g “Repeater” retransmit to “Meter” indicating a RL at (b) of (144 − 80)/2, i.e. RXL = 32.

h “Meter” receives at a RSSI of −70 dBm.

i “Meter” acknowledges to “Repeater” indicating a RL value at (h) of (144 − 70)/2 i.e. RXL = 37.

j “Repeater” retransmits to “Other Device”.

k Indicating an RSSI value at (f) of (144 − 50)/2 i.e. RXL = 47.

Figure 1 — Example of the usage of the RXL-field (using RSSI)

13.2.15 Payload Checksum Field (PayloadCRC-field)

The last two bytes of the extension block contain a CRC checksum of the remainder of the frame (excluding the CRC-fields of the link layer).

The CRC polynomial to use shall be $x^{16} + x^{13} + x^{12} + x^{11} + x^{10} + x^8 + x^6 + x^5 + x^2 + 1$.

The initial value shall be 0.

The final CRC shall be complemented.

13.3 CI-fields for the Transport Layer

13.3.1 General

A plain Transport Layer should be used for messages without application data. Otherwise, a combined Transport and Application Layer may be used. Multi byte fields shall be transmitted with low byte first.

13.3.2 Short Transport Layer

The Short Transport Layer (CI = $8A_h$) shall be applied for communication from Meter to Other Device (e.g. for a message ACK). The format shall be as shown in Table 57.

Table 57 — Short Transport Layer

CI	ACC	STS	Conf. Field
1 byte	1 byte	1 byte	2 bytes

13.3.3 Long Transport Layer

The Long Transport Layer (which includes the Application Layer Address, ALA) shall be applied for communication from the Meter to the Other Device (CI = $8B_h$; e.g. for a message type ACK) or from the Other Device to the Meter (CI = 80_h; e.g. for a message type REQ-UD2). The format shall be as shown in Table 58.

Table 58 — Long Transport Layer

CI	Ident no.	Manuf.	Ver.	Device Type	ACC	STS	Conf. Field
1 byte	4 bytes	2 bytes	1 byte	1 byte	1 byte	1 byte	2 bytes

14 Management functions for link control

14.1 General

Larger systems and many devices makes it advantageous to implement management facilities. The purpose of this is to increase the traffic capability by limiting the interference.

For the transfer of these management functions use CI-field reserved for Network Management, 82_h, 83_h, 87_h, 88_h and 89_h. See Table 42 for further details.

NOTE The CI values 83_h and 89_h are already previously assigned to this purpose. Management functions are defined in EN 13757-5 as well. The function fields defined in this part of the standard are aligned with the function fields defined in EN 13757-5:2015 Table 71.

The different Functions are illustrated in Table 59.

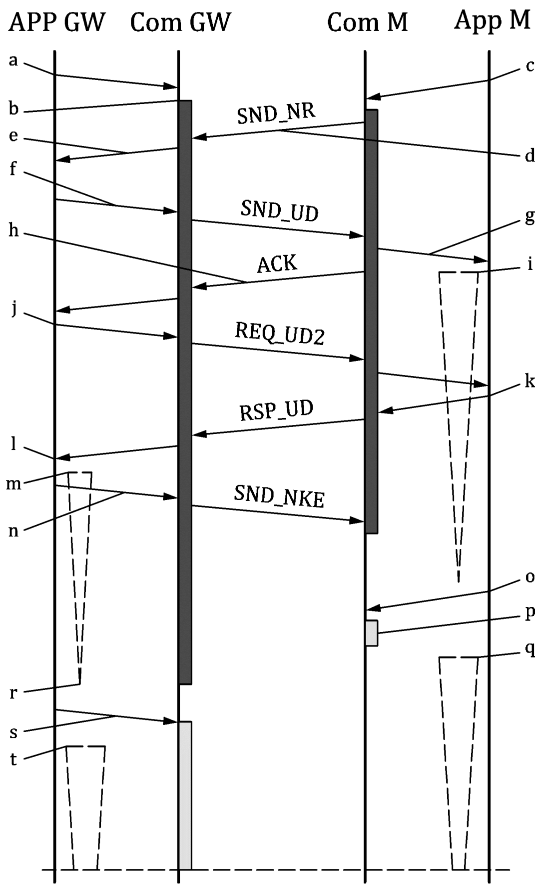
Table 59 — Function fields for the management of radio parameters

Function Field	Service
40_h	Set Radio Parameters
41_h	Get Radio Parameters
42_h	Set Limited Radio Parameters
43_h	Confirm Radio Parameters
44_h – $4E_h$	Reserved for Future Use
$4F_h$	Manufacturer Specific functions

Activation of these set functions may affect the operation of the overall network. Commands using these functions should be authenticated to mitigate the risk Denial-of-Service attacks. A CI = 82_h, 87_h or 88_h should be used to enable a secure transport of commands and responses using security services as specified in EN13757-7. The format of the Short Transport layer is shown in Table 57 above.

Some of the commands listed above changes the connection settings between the Meter and the Other Device, here named the Gateway. These commands may, if improperly executed, cause a loss of connection between the Meter and the Gateway. The protocol is designed to minimize the risk. There shall be an activation timeout. This shall be started when the command is dispatched / received at the application level. The timeout shall be long enough to ensure that the Meter as well as the Gateway will have time to perform retransmission in case of transmission errors.

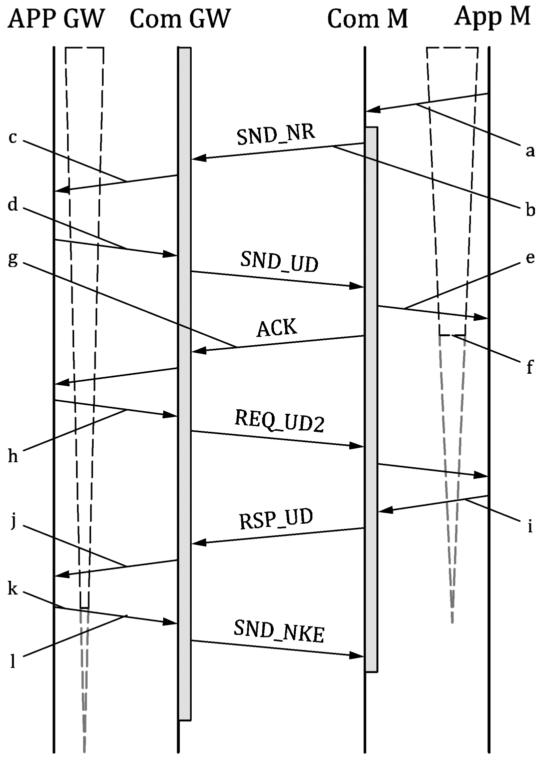
The flow of information during a change of radio parameters is shown in Figure 2 and Figure 3. It shows the actions at the Application level as well as on the Link level as the activities are initiated and controlled by the Network Management Application. The first figure shows the set up activity and activation of change. The next figure shows how the connection is established after the change of parameters.



Key

a The Gateway application, App GW, indicates to its Comm. module, Com GW, that want to send a message to the Meter.
b Com GW activates the receiver and wait for “transmit window” i.e. a periodic transmission from the Meter.
c “Meter application” App M, sends a periodical message.
d This transmitted by the Comm. module in the Meter, Com M, as a normal SND-NR frame to the Gateway.
e The Gateway receives the message, thereby knowing that the “transmit window” is open.
f The Gateway transmits the “Set Radio Parameters” command as a SND-UD frame. The decision of this may come from the Gateway or a Head End system.
g The Com M in the Meter gets the frame and passes it on to the application.
h The Meter confirms the frame at the link layer with an ACK.
i Decoding of the command in the Application starts the Activation timer in the Meter. The time shall be long enough to ensure a retry from the Meter in case of loss of response.
j Confirmation of the frame at link level makes the Gateway request the response to “Set Radio Parameters” from the Meter at application level.
k This message is received by the application in the Meter that responds.
l The Gateway receives the message.
m A non-error status makes the Gateway start the Activation timer in the Gateway.
n and close down the current connection by sending a SND-NKE frame. This will as well close down the receiver in the Meter.
o Time-out of the activation timer occurs in the Meter.
p Time-out AND the condition that the session has ended (n) will make the Meter reconfigure the radio with changed parameters,
q and start the fall-back timer in the Meter.
r Time-out of the activation timer occurs in the Gateway. This will deactivate the current connection,
s and activate a the new session with a changed configuration,
t and at the same time start the fall-back timer in the Gateway.

Figure 2 — Preparation for change of radio parameters



Key

a The meter starts transmitting periodic transmissions using the new radio parameters.

b It is sent as normal SND-NR frame with the new set up.

c A successful reception of the message by the Gateway. The decision of a successful reception may come from the Gateway Application or a Head End system.

d Makes it send a “Confirm Radio Parameters” command. It is sent as a SND-UD frame.

e Receiving and decoding the message.

f Makes the Meter stop its fall-back timer.

g Confirm the frame at Link level using ACK.

h The Gateway request status at application level using a REQ-UD.

i The Meter returns the status of the Confirm Parameters message in a RSP-UD.

j Receiving an error free response in the Gateway.

k Makes it turn off the fall-back timer

l and close down the connection using a SND-NKE.

Figure 3 — Start up after change of radio parameters

The Gateway or a Head End system behind the Gateway shall validate the connection after the change has been activated. The validation may vary from simply detecting frames using the new settings, to requiring the reception of multiple frames, with a very low error rate. There shall be a fall-back time. Disabling the fall-back timeout in the meter shall be done by the Gateway or Head End sending a Confirm Radio Parameters command. The Meter shall revert to the previous radio parameter settings if a Confirm Radio Parameters command is not received within the defined fall-back time.

14.2 Set Radio Parameters

14.2.1 General

This function is used to control the radio parameters, all of the parameters related to the radio link. These are parameters like mode, power and channel.

NOTE This command is supplemented by a limited version of the command "set limited radio parameter". The two commands are supposed to be used by different entities, with different levels of authorization.

The command execution shall be delayed by the Activation time, to ensure that the communication session has been finished before any radio parameters are changed.

14.2.2 Command

14.2.2.1 General

The format of the command is given in Table 60 and Table 61 below.

Table 60 —Format of Set Radio Parameters command, part 1

F-field	SF	SF2	Activation time	Fall-back time	(Mode)
40_h	1 byte	1 byte	5 bytes	5 bytes	(1 byte)

Table 61 —Format of Set Radio Parameters command, part 2

(Frame format)	(Tx-power)	(Tx-interval)	(Up-Channel)	(Down-Channel)	(Manuf)
(1 byte)	(1 byte)	(2 bytes)	(2 bytes)	(2 bytes)	(3 .. n byte)

All Fields except for SF, SF2, Activation Time and Fall-back time are conditional. They are only present if the corresponding bits are set in the SF field. Invalid values in a field shall make the receiver set the corresponding error bit and discard the entire command. The content of the different fields is as follows.

14.2.2.2 SF

The SF holds a bit-field that specifies what data that are present in the message. The function of the different bits in the SF-field is shown in Table 62 below.

Table 62 — SF field allocation

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
MO	FR	PWR	INT	UPCH	DNCH	MAN	RFUDEF

The different bits allocate data for the following:

MO: If set, then the Mode field is present in the message,

FR: If set, then the Frame format field is present in the message,

PWR: If set, then the Tx-Power is present in the message,

TxI: If set, then the Tx-Interval field is present in the message,

UPCH: If set, then the Up-Channel field is present in the message,

DNCH: If set, then the Down-Channel field is present in the message,

MAN: If set, then the Manuf field is present in the message,

RFU: reserved for future use and shall be binary "0".

14.2.2.3 SF2

SF2 is a bit-field similar to SF. It specifies the Enable bit for future fields. The function of the different bits in the SF2 field is shown in Table 63 below.

Table 63 — SF2 field allocation

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
RFU	RFU	RFU	RFU	RFU	RFU	RFU	RFU

RFU indicates reserved for future use and shall be binary "0".

14.2.2.4 Activation time

Specifies the time when the command execution shall be activated. It is, in case a relative time is used, the duration from the reception of the command to its execution. If the field contains the value 0 or a date in the past then the command shall be executed when the current session is over, i.e. activation of the change shall never be performed before the current session is over (see also 12.6.3.3). The activation time shall be coded as type M according to EN 13757-3:2018, Annex A.

14.2.2.5 Fall back time

Specifies the time within which the switching shall be validated by the Gateway or a Head End system behind the Gateway. Disabling the fall-back timer shall be performed by sending a Confirm Radio Parameters command. The Meter shall revert to the previous radio parameters if a Confirm Radio Parameters command is not received within the fall-back time. It is, in the case a relative time is used, the duration from the activation of the command and to its revocation. If the field contains the value 0 or a date in the past the fall back timeout is disabled. If the field contains the value <invalid>, the command shall be handled as if the field is not present in the command.

The fall back time shall be coded as type M, according to EN 13757-3:2018, Annex A.

14.2.2.6 Mode

It specifies, if present, the Mode to use after the change. The modes are coded as shown in Table 64:

Table 64 — Mode selection

Value	Data rate
00_h	Mode R
01_h	Mode S
02_h	Mode T
03_h	Mode C
04_h	Mode N
05_h	Mode F
06_h to FF_h	RFU

14.2.2.7 Frame format

Frame format specifies, if present, the Frame format to use after the change. It is coded as shown in Table 65.

Table 65 — Frame format selection

Value	Data rate
00_h	Format A
01_h	Format B
02_h to FF_h	RFU

14.2.2.8 Tx-power

Tx-power specifies the relative transmission power of the meter after the change. The power can be configured according to Table 66.

Table 66 — Configuration of Tx power

Parameter	Designation	Remarks
00_h	Max	Use maximum power level for the device
01_h	Level 1[a]	Use power level approximately 6 dB below maximum
02_h	Level 2[a]	Use power level approximately 12 dB below maximum
03_h	Level 3[a]	Use power level approximately 18 dB below maximum
04_h	Level 4[a]	Use power level approximately 24 dB below maximum
05_h – $0F_h$	Reserved	No impact to transmission power
10_h	Power constant	Power level remains unchanged
11_h	Increment power	Increase power level by a step of approximately 6dB
12_h	Decrement power	Decrease power level by a step of approximately 6dB
13_h – EF_h	Reserved	No impact to transmission power
$F0_h$ – FF_h	Manufacturer specific	Manufacturer specific settings of transmission power
[a] One or more power levels may be supported. If an unsupported power level is requested, then the next higher power level shall be selected.		

14.2.2.9 Tx-Interval

It specifies, if present, the nominal transmission interval in 2 s increments.

14.2.2.10 Up-Channel

It specifies for mode N and mode R the channel to use from Meter to Other Device. It shall be ignored for other modes. The Channel is coded as two bytes. The first byte holds the sub-mode index. For Mode N, this is specified in column “Index” in Table 21. For Mode R this shall be ‘00_h’. The second byte holds the channel (of the sub-mode).

14.2.2.11 Down-Channel

It specifies for mode N the channel to use from the Other Device to the Meter. It shall be ignored for all other modes. The Channel is coded as 14.2.2.10 Up-Channel.

14.2.2.12 Manuf

This field specifies manufacturer specific settings. The format is as shown in Table 67.

Table 67 — Format of manufacturer specific commands

Man. ID	Length	(Man.specific settings)
2 bytes	1 byte	*n* bytes

The two first bytes shall contain the Manufacturer ID as specified in 12.5.5. This shall be followed by a length field. A Meter shall be able to accept a length field with a value of ‘00_h’.

14.2.3 Response

14.2.3.1 General

The format of the response is given in Table 68.

Table 68 — Format of Set Radio Parameters response

F-field	SF	(Power level)	(Error report)	(Manuf. error report)
40_h	1 byte	1 byte	(1 byte)	(3 bytes)

The Power level, Error report field and Manuf. error report fields are conditional. They will only be present if the corresponding bit is set in SF.

14.2.3.2 SF

The function of the different bits in the SF field is shown in Table 69.

Table 69 — SF field allocation

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
Power	Error	Man	RFU	RFU	RFU	RFU	RFU

Power: Power level setting:

0 The device cannot report/handle power setting

1 The device can report/handle power settings

Error: Overall error status:

0 The command was successful and will be executed.

1 Error(s) occurred; the response contains a one byte error report with further data. Activation will not be performed if this bit is set.

Man: Manufacturer specific error status:

0 Fetching of the manufacturer specific part of command was successful and it will be executed.

1 There were errors in fetching the manufacturer specific part of the command. A manufacturer specific error byte follows.

RFU: Reserved for future use and shall be binary "0"

14.2.3.3 Power level

The transmit power level of the device; as shown in Table 70:

Table 70 — Used power level

Value	Designation	Remarks
00_h	Max	Uses maximum power level for the device
01_h	Level 1	Uses power level approximately 6 dB below maximum
02_h	Level 2	Uses power level approximately 12 dB below maximum
03_h	Level 3	Uses power level approximately 18 dB below maximum
04_h	Level 4	Uses power level approximately 24 dB below maximum
05_h – FF_h	Reserved	Reserved for future use

14.2.3.4 Error report

This field is present if errors occurred during execution of the command. The different bits are allocated as shown in Table 71. One or more bits may be set. A bit set indicates an error state.

Table 71 — Error report

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
Mode	Frame	Max	Min	Interv	Uplnk	Dnlnk	PwLvl

Mode:	0	No error in mode setting, if used,
	1	The requested mode cannot be selected.
Frame:	0	No error in frame format setting, if used,
	1	The requested frame format cannot be selected.
Max:	0	No error in power setting, if used,
	1	Maximum level has already been reached, power level not changed
Min:	0	No error in power setting, if used,
	1	Minimum level has already been reached, power level not changed
Interv:	0	No error in transmit interval setting, if used,
	1	The requested transmit interval could not be selected
Uplnk:	0	No error in selecting uplink channel, if used,
	1	The requested channel / sub-band in uplink direction cannot be selected.
Dnlnk:	0	No error in selecting downlink channel, if used,
	1	The requested channel / sub-band in downlink direction cannot be selected.
PwLvl:	0	No error in selecting power level, if used,
	1	The requested power level cannot be selected. The power level byte, see Table 70 holds the actual level.

14.2.3.5 Manuf. error report

Activation of manufacturer specific action will not be performed if this bit is set. The content is the Manufacturer ID, as specified in 12.5.5, followed by an error byte. The coding of the error byte is manufacturer specific.

14.3 Get Radio Parameters

14.3.1 General

This function is used to return the setting of the radio parameters, the parameters related to the radio link. This is parameters like mode, power and channel.

14.3.2 Command

14.3.2.1 General

The command shall return all of the parameters available in the Meter. The value returned will be the value pending if there are pending parameter changes.

The format of the command is given in Table 72 below.

Table 72 —Format of Get Radio Parameters command

F-field	SF
41_h	1 byte

14.3.2.2 SF

The SF is a dummy parameter. It shall be 00_h.

14.3.3 Response

14.3.3.1 General

The format of the response uses the same structure as the corresponding command. It is given in Table 73 and Table 74.

Table 73 —Format of Get Radio Parameters response, part 1

F-field	SF	SF2	Activation time	Fall-back time	Mode
41_h	1 byte	1 byte	5 bytes	5 bytes	1 byte

Table 74 —Format of Get Radio Parameters response, part 2

Frame format	Tx-power	(Tx-interval)	(Up-Channel)	(Down-Channel)	(Manuf)
1 byte	1 byte	(2 bytes)	(2 bytes)	(2 bytes)	(3 .. *n* byte)

All Fields but Tx-Interval, Up-Channel, Down-Channel and Manuf are mandatory. Tx-Interval, Up-Channel, Down-Channel and Manuf are only present if the corresponding bits are set in the SF field. The content of the different fields is as follows.

14.3.3.2 SF

The SF holds a bit-field that specifies what data that are present in the message. The function of the different bits in the SF-field is shown in Table 75 below.

Table 75 — SF field allocation

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
MO	FR	PWR	INT	UPCH	DNCH	MAN	ERR

The different bits represent the following:

MO: Always “1”, as the Meter is using a specific Mode,

FR: Always “1”, as the Meter is using a specific Frame format,

PWR: Always “1”, as the Meter has a the Tx-Power setting,

TxI: If set, then a Tx-Interval setting is available,

UPC: If set, then an Up-Channel setting is available,

DNC: If set, then a Down-Channel setting is available,

MAN: If set, then the Manuf specific settings are available,

ERR: There was an error in responding to the command. No data will be returned.

NOTE This could be that case if the command isn't implemented in the Meter.

14.3.3.3 SF2

The SF is a dummy parameter. It shall be 00_h.

14.3.3.4 Activation time

It specifies the currently loaded activation time. See 14.2.2.4 for format and details.

14.3.3.5 Fall back time

It specifies the currently loaded fall back time. See 14.2.2.5 for format and details.

14.3.3.6 Mode

It specifies the current mode of the device. The value returned will be the value pending if there are pending parameter changes. See 14.2.2.6 for coding and details.

14.3.3.7 Frame format

It specifies the current frame format of the device. The value returned will be the value pending if there are pending parameter changes. See 14.2.2.7 for coding and details.

14.3.3.8 Tx-power

It specifies the current relative transmission power of the meter. The value returned will be the value pending if there are pending parameter changes. See 14.2.2.8 for coding. The value shall be in the range 00_h to 04_h.

14.3.3.9 Tx-Interval

It specifies, if present, the current nominal transmission interval in 2 s increments. The value returned will be the value pending if there are pending parameter changes.

14.3.3.10Up-Channel

It specifies, if present, the channel used from Meter to Other Device. The value returned will be the value pending if there are pending parameter changes. See 14.2.2.10 for coding and details.

14.3.3.11 Down-Channel

It specifies for mode N the channel used from the Other Device to the Meter. The value returned will be the value pending if there are pending parameter changes. See 14.2.2.10 for coding and details.

14.3.3.12 Manuf

This field specifies, if present, manufacturer specific settings used with respect to channel switching. The value returned will be the value pending if there are pending parameter changes. See 14.2.2.12 for coding and details.

14.4 Set limited radio parameters

14.4.1 General

This function is used to control a limited number of radio parameters.

NOTE This command is a limited version of the command “set radio parameter”. The two commands are supposed to be used by different entities, with different levels of authorization.

The syntax and semantics of the command follows that of “Set Radio Parameters”. The execution of the command shall be delayed to get the communication session finished. In case the communication link gets lost, due to the command execution the meter shall fall back to the previous channel setting after a predefined timeout.

14.4.2 Command

14.4.2.1 General

The format of the command is given in Table 76 and Table 77 below. It follows that of “Set Radio Parameters”.

Table 76 —Format of Set Limited Radio Parameters command, part 1

F-field	SF	SF2	Activation time	Fall-back time	(Mode)
40_h	1 byte	1 byte	5 bytes	5 bytes	(1 byte)

Table 77 —Format of Set Limited Radio Parameters command, part 2

(Frame format)	(Tx-power)	(Tx-interval)	(Up-Channel)	(Down-Channel)	(Manuf)
(1 byte)	(1 byte)	(2 bytes)	(2 bytes)	(2 bytes)	(3 .. *n* byte)

NOTE Mode and Frame format are do not care bytes in the limited version as they cannot be changed here.

All Fields but SF, SF2, Activation Time and Fall-back time are conditional. They are only present if the corresponding bits are set in the SF field. Invalid values in a field shall make the receiver set the corresponding error bit and discard the command. The content of the different fields is as follows.

14.4.2.2 SF field

The SF-field holds a bit-field that specifies what data that are present in the message. The function of the different bits in the SF-field is shown in Table 78 below. The interpretation of the different bits is specified in 14.2.2.2. Bits specified as “0” cannot be set using this command.

Table 78 — SF bit allocation

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
“0”	“0”	PWR	INT	UPCH	DNCH	MAN	“0”

14.4.2.3 SF2

SF2 is defined in 14.2.2.3

14.4.2.4 Activation time

It specifies the current setting of activation time. See 14.2.2.4 for details

14.4.2.5 Fall back time

It specifies the setting fall-back time-out. See 14.2.2.5 for details.

14.4.2.6 Tx-power

It specifies the relative setting of power level. See 14.2.2.8 for details.

14.4.2.7 Tx - interval

It specifies, for synchronous transmission interval in 2 s increments. See 14.2.2.9 for details.

14.4.2.8 Up-Channel

It specifies, if present, the uplink channel to use. See 14.2.2.10 for details.

14.4.2.9 Manuf

It specifies, if present manufacturer specific information. See 14.2.2.12 for details.

14.4.3 Response

14.4.3.1 General

The format of the Set Limited Radio Parameters response is given in Table 79 below.

Table 79 — Format of Set Limited Radio Parameters response

F-field	SF	Power level	(Error report)	(Manuf error report)
42_h	1 byte	1 byte	(1 byte)	(1 byte)

The Error report field and Manuf. error report fields are conditional. They will only be present if the corresponding bit is set in SF.

14.4.3.2 SF

The SF field is specified in 14.2.3.2.

14.4.3.3 Power level

The Power level is specified in 14.2.3.3

14.4.3.4 Error report

This field is specified in 14.2.3.4

14.5 Confirm Radio Parameters

14.5.1 General

This function is used to confirm the selected parameter settings after the communication has been established again with the new parameter settings. This can disable or extend the fall-back timer.

14.5.2 Command

14.5.2.1 Format

The format of the request is given in Table 80 below.

Table 80 —Format of Confirm Radio Parameters command

F-field	SF	(Fall-back time)
43_h	1 byte	(5 bytes)

14.5.2.2 SF

The function of the different bits in the SF field is shown in Table 81 below.

Table 81 — SF bit allocation

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
RFU	RFU	RFU	RFU	RFU	RFU	RFU	TIM

TIM: 0 = No fall-back time is included in the frame. This is at the same time a confirmation of the command and thereby a disabling of the fall-back timer.

1 = A value of the Fall-back time is included in the frame. This is the new fall-back time.

RFU: reserved for future use and shall be binary "0"

14.5.2.3 Fall-back time

Specifies the time until the fall-back action shall occur. It is in the case of a relative time, the duration from the current point in time. A value of “0” will disable the timer. This is a confirmation of the change command. The value <invalid>, a negative relative value or a date in the past shall be ignored and shall generate an error report. These values shall not disable the fall-back timer. A positive relative time or a time in the future will extend the duration of the armed fall-back action. This can be used to prolong the fall-back time to achieve a better assurance of the quality of the connection.

The fall-back time shall be coded as type M, according to EN 13757-3:2018, Annex A.

14.5.3 Response:

14.5.3.1 Format

The format of the Confirm Radio Parameters response is given in Table 82 below.

Table 82 — Format of Confirm Radio Parameters response

F-field	SF	(Error report)
43_h	1 byte	(1 byte)

The error report field is conditional.

14.5.3.2 SF

The function of the different bits in the SF field is shown in Table 83 below.

Table 83 — SF bit allocation

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
Error	RFU	RFU	RFU	RFU	RFU	RFU	RFU

Error: Overall error status:

0 The request was successful

1 Error(s) occurred, the response contains an error byte with further data.

RFU: reserved for future use and shall be binary "0"

14.5.3.3 Error report

This field is only included in the frame if the Error bit is set in SF. The different bits are allocated as shown in Table 84. One or more bits may be set. A bit set indicates an error state.

Table 84 — Error report allocation

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
RFU	RFU	RFU	RFU	RFU	RFU	RFU	Fall-back time error

RFU: reserved for future use and shall be binary "0"

Fall-back time error: If this bit is set, then it was not possible to set the fall-back timer to the specified value. The fall-back timer is not disabled if this occurs.

14.6 Set manufacturer specific parameters

14.6.1 General

This function is allocated to manufacturer specific communication.

14.6.2 Command

14.6.2.1 Format

The format of the command is given in Table 85 below.

Table 85 — Format of manufacturer specific commands

F-field	SF	Man. ID	Len	(Man.spec. fields)
$4F_h$	1 byte	2 bytes	1 byte	(*n* bytes)

There may be one or more Man. specific fields. They are conditional. They are only present if a corresponding bit is set in the SF-field. The content of the different fields is as follows:

14.6.2.2 SF

The function of the different bits in the SF-field is shown in Table 86 below. It makes it possible to enable up to 8 different set of manufacturer data. The data element will only be present in the message if the corresponding bit is set in the SF-field. The actual bit-allocation in the SF-field is manufacturer specific.

Table 86 — SF-field allocation

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
Man. spec.	Man. spec.	Man. spec.	Man. spec.	Man. spec.	Man. spec.	Man. spec.	Man. spec.

The usage of the individual bits in SF-field is manufacturer specific.

14.6.2.3 Man.ID

The purpose of this field is to limit the risk of incorrect operations due to different functionalities for different manufacturers. The field shall contain the Manufacturer ID as specified in 12.5.5.

14.6.2.4 Len

This is the length of the manufacturer specific data. The field may have the value 0, i.e. no data follows.

14.6.2.5 Man. Spec. fields

One or more manufacturer specific fields may follow. The size and content is manufacturer specific.

14.6.3 Response

14.6.3.1 Format

The format of the “manufacture specific” response is given in Table 87 below.

Table 87 — Format of Manufacture Specific response

F-field	SF	Man. ID	Length	(Manuf. specific report)
$4F_h$	1 byte	2 bytes	1 byte	(*n* byte)

The Manuf. specific report field is conditional.

14.6.3.2 SF

The function of the different bits in the SF is shown in Table 88 below.

Table 88 — SF bit allocation

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
Man. spec.	Man. spec.	Man. spec.	Man. spec.	Man. spec.	Man. spec.	Man. spec.	Man. spec.

The usage of the individual bits in the SF-field is manufacturer specific.

14.6.3.3 Manufacturer Specific report

The usage of this field is manufacturer specific.

Annex A
(informative)

Frequency allocation and band usage for the 868 MHz band

The allocation of frequencies for different services is shown in Figure A.1 below;

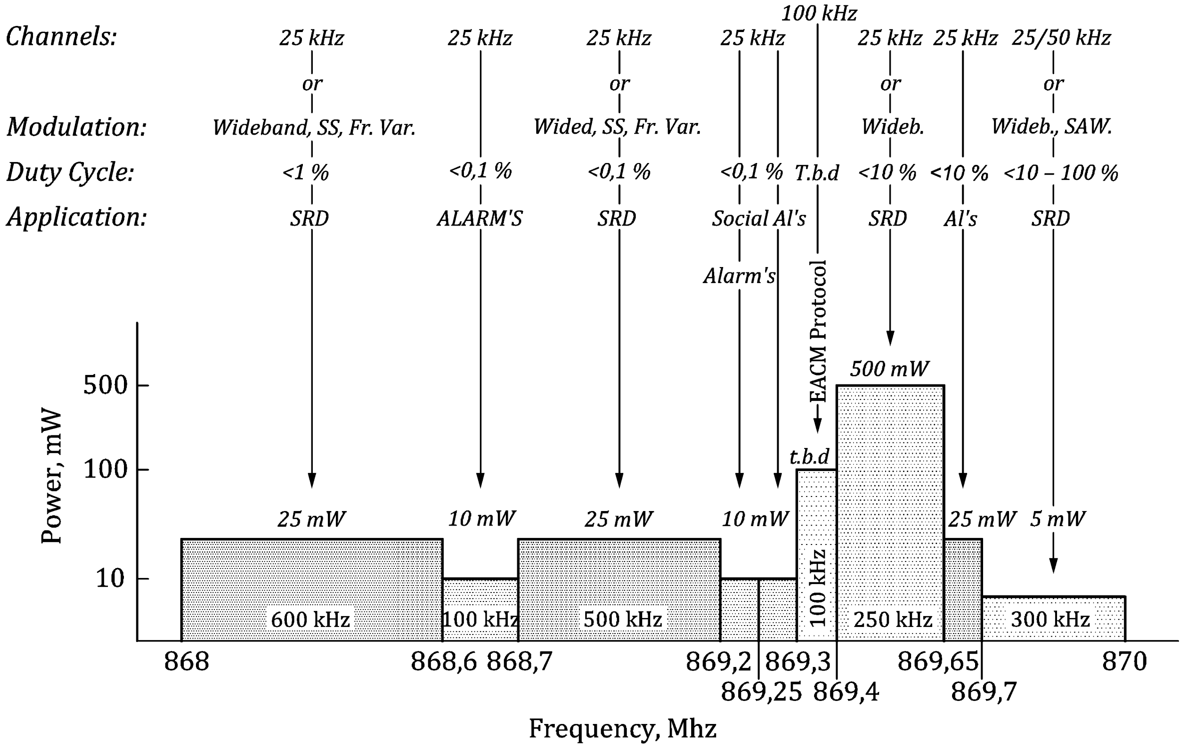


Figure A.1 — Frequency allocation and band usage for the 868 MHz band

Annex B
(informative)

Frequency allocation for the 169 MHz band

B.1 Frequencies and allowed power levels

An overview of the allowed power levels for the different parts of the frequency band is shown on Figure B.1 below. The value is shown in dBm. The number of the different allocations refers to the annex and band numbering in ERC/REC 70-03, i.e. An2-b refers to Annex 2, band b.

Allocated band An1-f3 does not allow concentrators.

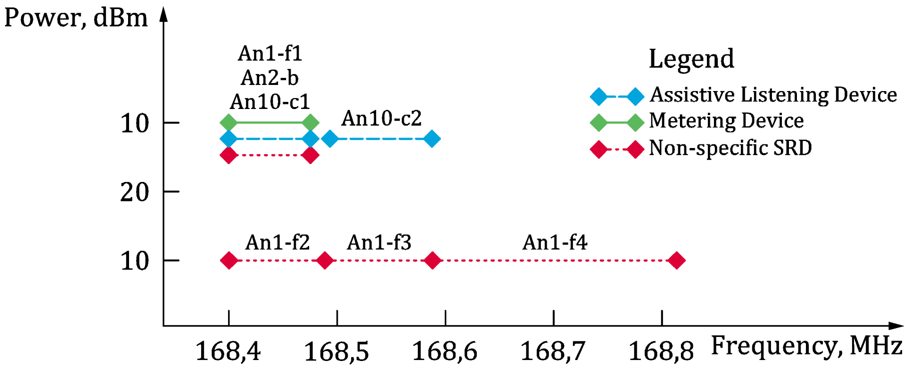


Figure B.1 — Frequencies and allowed power levels

B.2 Frequencies and allowed duty cycles

An overview of the allowed duty cycle, for the different parts of the frequency band, is shown on Figure B.2 below. The scale of the duty cycle is logarithmic. The number of the different allocations refers to the annex and band numbering in ERC/REC 70-03, i.e. An2-b refers to Annex 2, band b.

Allocated band An1-f3 does not allow concentrators. Allocated band An1-f3 allows for a duty cycle of 0,1 % in the local time period 00:00 to 06:00.

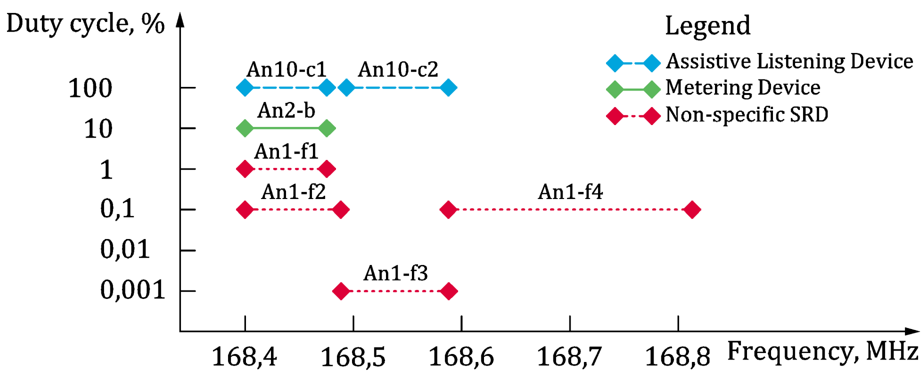


Figure B.2 — Frequencies and allowed duty cycles

Annex C
(informative)

Frame examples

C.1 Example of a frame from a meter in mode S

C.1.1 Conditions

The link layer frame length L (except the L-field and the CRC's) is 9 + 6 = 15 bytes (see below). The C-field has the value 044_h ("SEND/NO REPLY, Meter initiative").

A meter from a (dummy) manufacturer "CEN" with a unique (hexadecimal) manufacturer number 12345678_h; 01_h; 07_h (Identification-number; Version; Device type) transmits a (decimal) volume of 876 543 l.

For the example, this is coded according to EN 13757-3 as: DIF = $0B_h$ (= 6 digit BCD instantaneous value) and VIF = 13_h (= volume in litres).

The "CEN" is coded according to EN 13757-7 as "C" = (43_h−40_h) = 3, "E" = 5, "N" = 14. Thus "CEN" = 32 × 32 × 3 + 32 × 5 + 14 = 3246 = $0CAE_h$. Most significant bit is null since it is a "hard" (i.e. manufacturer unique) address.

C.1.2 Block content

The frame consists of two blocks:

a) The first block, as defined in 12.3, Figure 2, consists of 10 byte (by definition of this document) and 2 CRC bytes:

   1) $0F_h$ L-field according to EN 60870-5-1;

   2) 44_h C-field according to EN 60870-5-2;

   3) $0CAE_h$ Manufacturer code;

   4) 12345678_h; 01_h; 07_h Manufacturer number (Identification-number; Version; Device type).

b) The second block consists of the CI-field plus, 5 user bytes and 2 CRC bytes:

   1) 78_h CI-field, without header, start immediately with VIF/DIF;

   2) $0B_h$ DIF = 3 byte BCD instantaneous value;

   3) 13_h VIF = Volume in litres;

   4) 876543_h = Number of litres (in BCD).

Since multi byte data shall be transmitted with LSB first, then the hex byte sequences without CRC's are:

— 0F 44 AE 0C 78 56 34 12 01 07 1. block;

— 78 0B 13 43 65 87 2. block.

The CRC according to FT3 of EN 60870-5-1 uses:

$$x^{16} + x^{13} + x^{12} + x^{11} + x^{10} + x^{8} + x^{6} + x^{5} + x^{2} + 1$$

as a generator polynomial. It starts with zero and treats the data most significant bit first. The CRC result is complemented. The most significant byte of the 16-bit CRC is transmitted first.

The full hex byte string is then:

0F 44 AE 0C 78 56 34 12 01 07 44 47 78 0B 13 43 65 87 1E 6D

C.1.3 Bit string

Coding each bit via the Manchester code results in:

1010101001010101	1001101010011010	0110011001010110	1010101001011010
1001010101101010	1001100110010110	1010010110011010	1010100110100110
1010101010101001	1010101010010101	1001101010011010	1001101010010101
1001010101101010	1010101001100101	1010100110100101	1001101010100101
1001011010011001	0110101010010101	1010100101010110	1001011001011001

Together with the header (S1 long), the bit-sync pattern and the trailer this leads to the following total continuous chip string:

0101010101010101010101010101010101010101010101010101010101010101

0101010101010101010101010101010101010101010101010101010101010101

0101010101010101010101010101010101010101010101010101010101010101

0101010101010101010101010101010101010101010101010101010101010101

0101010101010101010101010101010101010101010101010101010101010101

0101010101010101010101010101010101010101010101010101010101010101

0101010101010101010101010101010101010101010101010101010101010101

0101010101010101010101010101010101010101010101010101010101010101

0101010101010101010101010101010101010101010101000111011010010110

1010101001010101100110101001101001100110010101101010101001011010

1001010101101010100110011001011010100101100110101010100110100110

1010101010101001101010101001010110011010100110101001101010010101

1001010101101010101010100110010110101001101001011001101010100101

1001 01101001100101101010100101011010100101010110100101100101100101

which contains a total of 898 chips. For mode S1 communication with a nominal chip rate of 32,768 kcps the transmit duration will be 27,4 ms

C.2 Example of a frame from a meter in mode T1

C.2.1 Condition

The link layer frame length L (except the L-field and the CRC's) is 9 + 6 = 15 bytes (see below). The C-field has the value 044_h ("SEND/NO REPLY, Meter initiative").

A meter from a (dummy) manufacturer "CEN" with a unique (hexadecimal) manufacturer number 12345678_h; 01_h; 07_h Manufacturer number (Identification-number; Version; Device type) transmits a (decimal) volume of 876 543 l.

For the example, this is coded according to EN 13757-3 as: DIF = $0B_h$ (= 6 digit BCD instantaneous value) and VIF = 13_h (=volume in litres).

The "CEN" is coded according to EN 13757-7 as "C" = (43_h-40_h) = 3, "E" = 5, "N" = 14. Thus "CEN" = 32 × 32 × 3+32 × 5+14 = 3246 = $0CAE_h$. Most significant bit is null since it is a "hard" (i.e. manufacturer unique) address.

C.2.2 Block Content

The frame consists of two blocks:

a) The first block, as defined in Figure 2, consists of 10 bytes (by definition of this document) and 2 CRC bytes:

   1) $0F_h$ L-field according to EN 60870-5-1;

   2) 44_h C-field according to EN 60870-5-2;

   3) $0CAE_h$ Manufacturer code;

   4) 12345678_h; 01_h; 07_h Manufacturer number (Identification-number; Version; Device type).

b) The second block consists of the CI-field, 5 user bytes and 2 CRC bytes:

   1) 78_h CI-field, without header, start immediately with VIF/DIF;

   2) $0B_h$ DIF = 3 byte BCD instantaneous value;

   3) 13_h VIF = Volume in litres;

   4) 876543_h = Number of litres (in BCD).

Since multi byte data (according to EN 13757-3) shall be transmitted with LSB first, the hex byte sequences without CRC´s are:

— 0F 44 AE 0C 78 56 34 12 01 07 1. block;

— 78 0B 13 43 65 87 2. block.

The CRC according to FT3 of EN 60870-5-1 uses:

$x^{16} + x^{13} + x^{12} + x^{11} + x^{10} + x^8 + x^6 + x^5 + x^2 + 1$

as a generator polynomial. It starts with zero and treats the data 'most' significant bit first. The CRC result is complemented. The most significant byte of the 16-bit CRC is transmitted first.

The full hex byte string is then:

0F 44 AE 0C 78 56 34 12 01 07 44 47 78 0B 13 43 65 87 1E 6D

C.2.3 Bit string

Coding each nibble via a 6 chip code according to the coding table results in:

010110	101001	011100	011100	100110	110010	010110	110100
010011	101100	011001	011010	001011	011100	001101	001110
010110	001101	010110	010011	011100	011100	011100	010011
010011	101100	010110	100011	001101	001011	011100	001011
011010	011001	101100	010011	001101	110010	011010	110001

Together with the header, the bit synchronization pattern and the trailer this leads to the following total continuous chip string:

010101010101010101010101010101010101010000111101

010110101001011100011100100110110010010110110100

010011101100011001011010001011011100001101001110

010110001101010110010011011100011100011100010011

010011101100010110100011001101001011011100001011

01101001100110110001001100110111001001101011000101

which contains a total of 290 chips. For mode T1 with a nominal chip rate of 100 kcps, the transmit duration will be 2,9 ms

C.3 Example of a frame from a meter in mode C1

C.3.1 Conditions

In this example, the frame is in format B and it uses the Extended Link Layer with CI-field $8C_h$.

The link layer frame length L (except the L-field) is 20 bytes (see below).

The C-field has the value 44_h ("SEND/NO REPLY, Meter initiative").

A meter from a (dummy) manufacturer "CEN" with a unique (hexadecimal) manufacturer number 12345678_h; 01_h; 07_h Manufacturer number (Identification-number; Version; Device type) transmits a (decimal) volume of 876 543 l.

For the example, this is coded according to EN 13757-3 as: DIF = $0B_h$ (= 6 digit BCD instantaneous value) and VIF = 13_h (= volume in litres).

The "CEN" is coded according to EN 13757-7 as "C" = (43_h − 40_h) = 3, "E" = 5, "N" = 14. Thus "CEN" = 32 × 32 × 3+32 × 5 + 14 = 3246_d = $0CAE_h$. Most significant bit is null since it is a "hard" (i.e. manufacturer unique) address.

The “Communication Control Field” of the Link Layer Extension is CC = 20_h specifying that this is a synchronized frame. The counting “ACC Number Field” is in this example ACC = 27_h.

C.3.2 Block content

Since the total length of the frame including the L-field and the CRC-field is less than 128, the frame consists of only one block as shown in Figure C.1.

L-field	C-field	M-field	A-field	CI-field	CC-field	ACC-field
14_h	44_h	$0CAE_h$	12345678_h;01_h;07_h	$8C_h$	20_h	27_h

...

...

CI-field	DIF-field	VIF-field	Data-field	CRC-field
78_h	$0B_h$	13_h	876543_h	$7AC5_h$

Figure C.1 — Mode C format B block content

Since multi byte data shall be transmitted with LSB first, the hex byte sequences without CRC are:

14 44 AE 0C 78 56 34 12 01 07 8C 20 27 78 0B 13 43 65 87

The CRC according to this standard uses:

$$x^{16} + x^{13} + x^{12} + x^{11} + x^{10} + x^{8} + x^{6} + x^{5} + x^{2} + 1$$

as a generator polynomial. It starts with zero and treats the data ‘most’ significant bit first. The CRC result is complemented. The most significant byte of the 16-bit CRC is transmitted first.

The full hex byte string is then:

14 44 AE 0C 78 56 34 12 01 07 8C 20 27 78 0B 13 43 65 87 7A C5.

C.3.3 Bit string

Coding each byte via NRZ with the most significant bit first results in:

0001 0100 0100 0100 1010 1110 0000 1100

0111 1000 0101 0110 0011 0100 0001 0010

0000 0001 0000 0111 1000 1100 0010 0000

0010 0111 0111 1000 0000 1011 0001 0011

0100 0011 0110 0101 1000 0111 0111 1010

1100 0101

Together with the preamble and synchronization this leads to the following total continuous chip string:

0101010101010101010101010101010101010000111101010101000011101
0001010001000100101011100000110001111000010101100011010000010010
0000000100000111100011000010000000100111011110000000101100010011
01000011011001011000011101111010110001 01

which contains a total of 232 chips.

For mode C1 with a nominal chip rate of 100 kcps, the transmit duration will be 2,32 ms.

Annex D
(informative)

Example of predictive reception of synchronous messages

To synchronize with the synchronous transmissions of a Meter, it is required to receive at least two synchronous messages. To do so with a reasonable failure rate, a continuous reception period of six nominal transmission intervals is recommended. Since the maximum of the nominal transmission interval is restricted e.g. in Mode T to 15 min, 90 min of continuous reception are adequate.

EXAMPLE Two synchronous messages with the access number values 110 and 112 have been received at a time difference of 1 661,563 s. This is illustrated in Figure D.1 below. From the access number values it can be seen that one message has been missed. Thus, the individual transmission interval between the two messages is:

$$t_{110} + t_{111} = 1661,563 \text{ s}$$

$$= \left(1 + \left(\left|110 - 128\right| - 64\right) / 2048\right) \times t_{\mathrm{NOM}} + \left(1 + \left(\left|111 - 128\right| - 64\right) / 2048\right) \times t_{\mathrm{NOM}}$$

$$= \left(1 + \left(-46 / 2048\right) + 1 + \left(-47 / 2048\right)\right) \times t_{\mathrm{NOM}}$$

Now the nominal transmission interval, t_{NOM}, can be determined:

$$t_{\mathrm{NOM}} = 1661,563 \text{ s} \times 2048 / \left(2048 - 46 + 2048 - 47\right) = 850,083 \text{ s}$$

The integer factor is $n = 425$.

With the nominal transmission interval, the expected individual transmission interval to the next synchronous transmission t_{112} can be determined:

$$t_{112} = \left(1 + \left(\left|112 - 128\right| - 64\right) / 2048\right) \times 850,083 \text{ s} = 830,159 \text{ s}$$

The nominal transmission interval for that meter can be recalculated after every reception of a new synchronous message of that meter to compensate temperature drift.

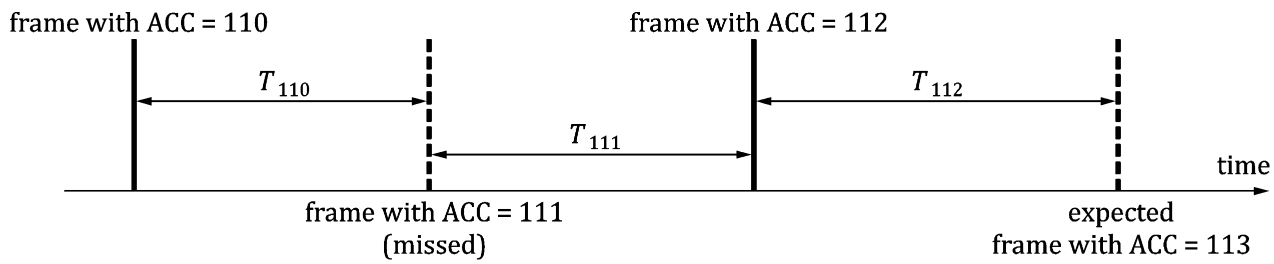


Figure D.1 — Prediction of the synchronous transmission time

Annex E
(informative)

Timing diagrams

The next pages show examples of timing diagrams for installation or data transfer. Figure E.1 is an explanation of how to read the timing diagram. Figures E.2 to E.7 present the generic timing.

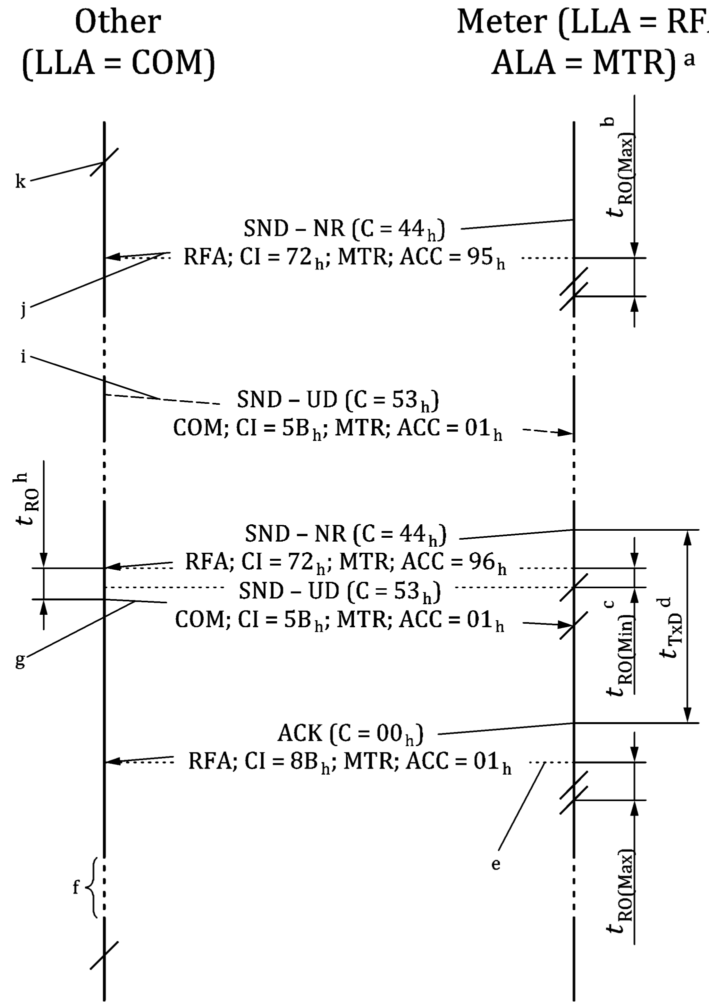
The Figures E.8 to E.11 present the special timing of the mode C with emphasis on the handling of the special data elements Frame Number (FN) and Hop Count (H).

Figures E1, E.2, E.7, E.12 and E.13 are applicable to all modes. Figures E.3 to E.6 are only applicable to modes S, T and N. Figures E.8 to E.11 are only applicable to mode C.

Figure E.12 and E.13 show the timing of broadcast of multicast frames using the SND-UD3 command.

Special abbreviations used in this annex are; LLA = Link Layer Address, ALA = Application Layer Address, MTR = Meter, COM = Data Collector/Concentrator, OMC = Other Meter Collector, RFA = Radio Frequency Adapter.

The different access timing of alternative reception windows has to be considered.



Key

a LLA = Link Layer Address

ALA = Application Layer Address.

In this example the LLA is the address from the RF-adapter “RFA” and the Meter Application Address is “MTR”.

b The reception window of the meter closes after $t_{RO(Max)}$ e.g. 3 ms (mode T).

c The reception window of the Meter opens after $t_{RO(Min)}$ e.g. 2 ms for mode T.

d A delay of t_{TxD} s.

e A dotted help line shows a synchronous event for sender and receiver. E.g. the start of the timeout for the reception windows, when the Transmission was finished.

f Time gap

g The Other Device with address “COM” sends a message of type “Send User Data” to the Meter with address “MTR” and uses an Access counter “1”.

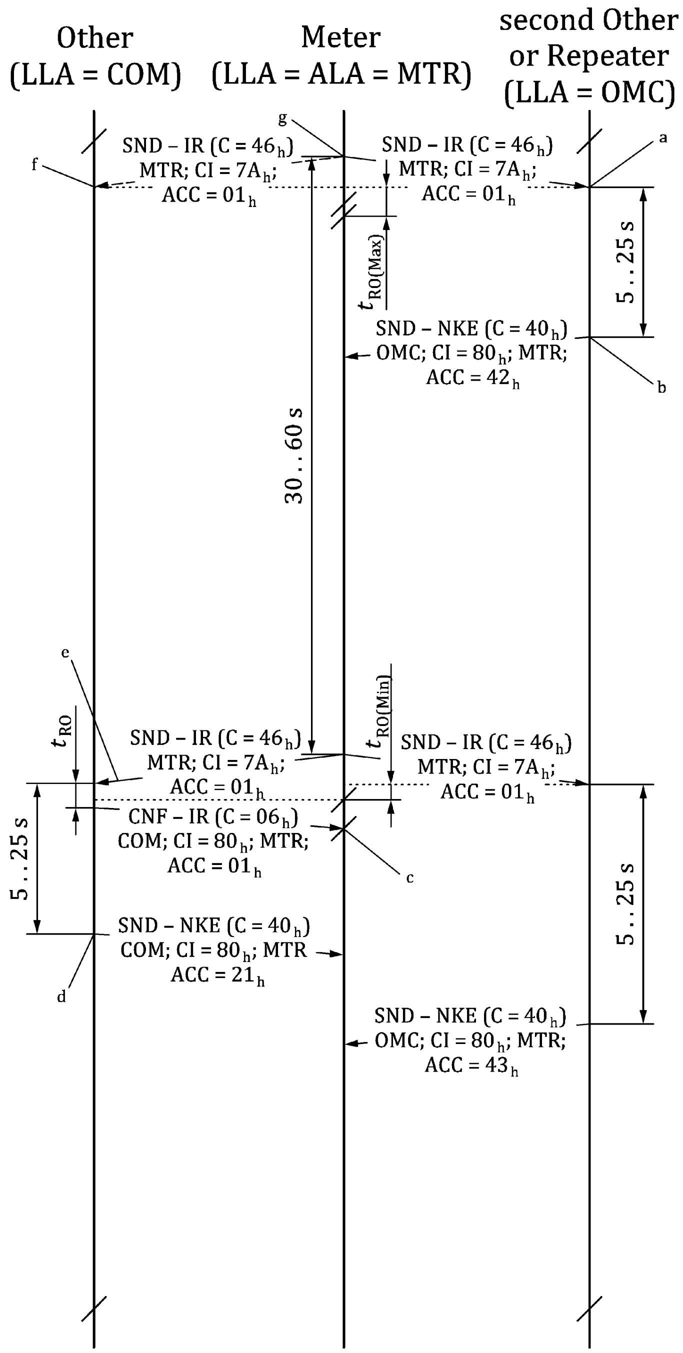
h The Other Device has to send the answer within t_{RO} (between 2nd and 3rd ms for mode T).

i The dashed line means the message was transmitted but not received.

j The continuous line means the message was successful received.

k The Other Device has the receiver continuously open!

Figure E.1 — Legend of how to read the timing diagram



Key

a The second Other Device does not accept this Meter.

b However it sends a Link-reset after every reception of an installation request from the new installed meter after a random delay! This message signals an available radio link to an optional Service tool.

c If the Meter receives the dedicated confirmation to its installation request it stops the transmission of installation request messages.

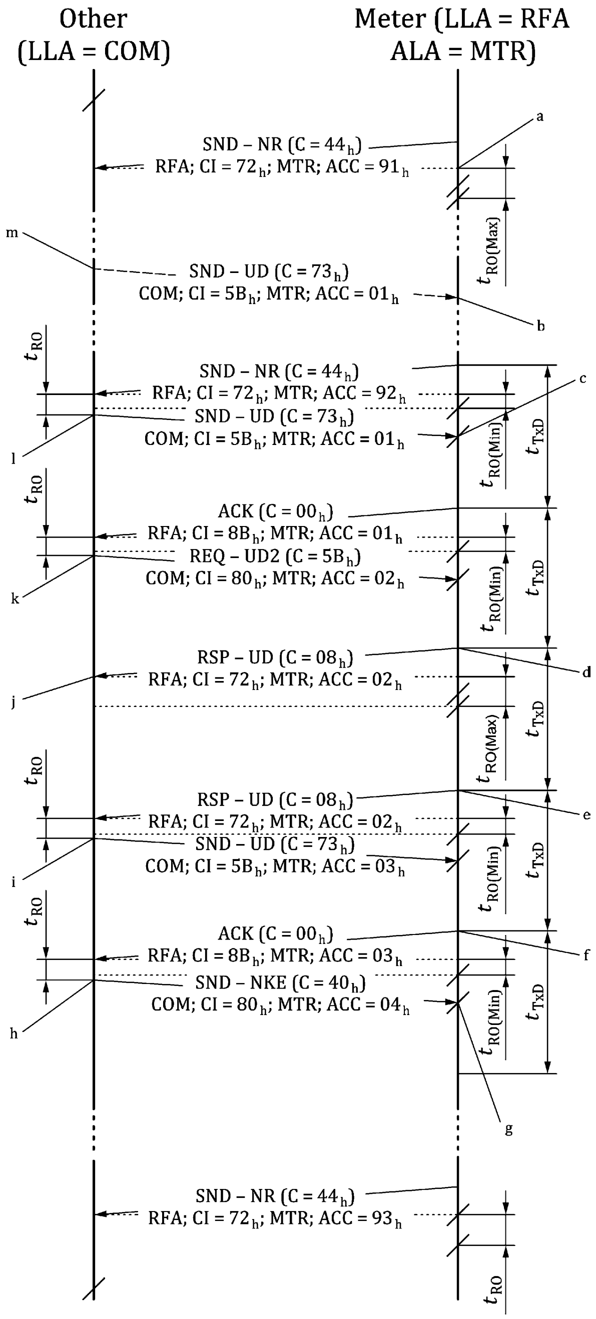
d For a uniform behaviour the assigned Other Device sends a Link-reset after a random delay too.

e The Other Device accepts this Meter. Hence it responds with an installation confirmation. An optional service tool may use this message to signal, that the Meter is logged in the COM.

f The Other Device fails to receive the Meter.

g During the installation mode the Meter generates periodical message of the type “Installation request” until the reception of the installation confirmation (CNF-IR) or the timeout.

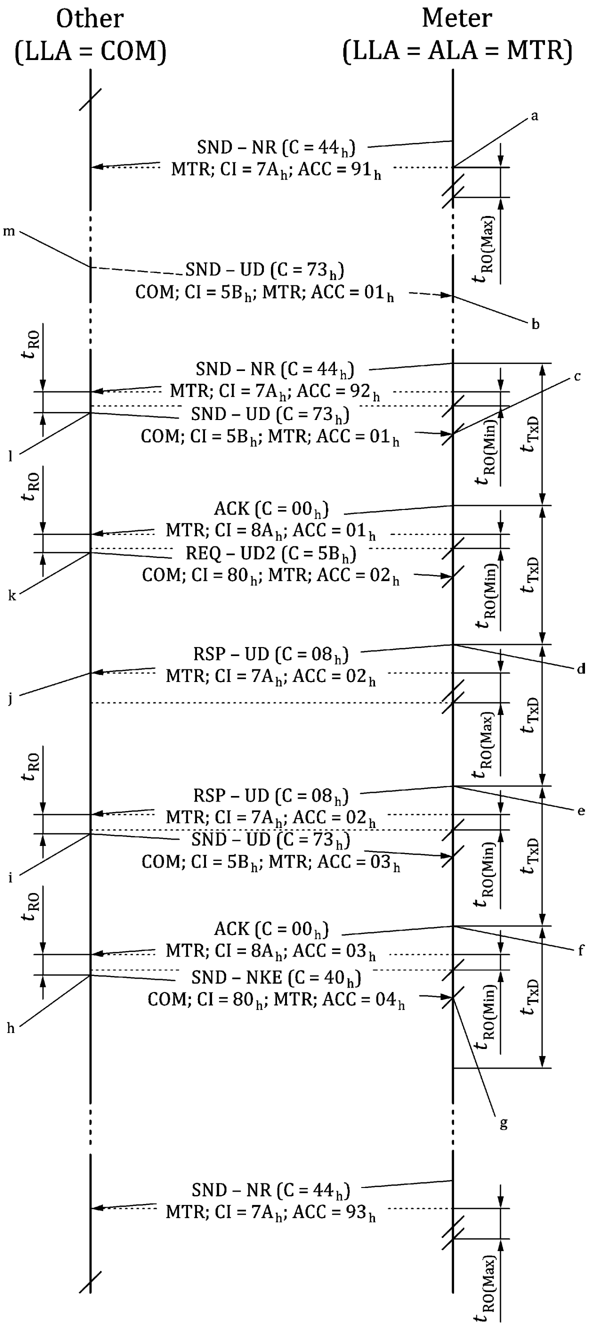
Figure E.2 — Installation timing



Key

a A short reception windows follows after every transmission (if Bit B = 1 and Bit A = 0 in Configuration Field).
b Since the receiver is not always open, the message is not received.
c The message was received now. An acknowledge is responded with a predefined delay.
d The Meter generates a response after the predefined delay.
e The Meter does not receive the response and repeats the last message again after the predefined delay.
f The Meter now receives a new command and generates an acknowledge after the predefined delay.
g The Meter receives a SND-NKE (means “End of Transmission”). It stops the frequent access cycle.
h The Other Device receives the acknowledge and finishes the session.
i When the Meter allows access the Other Device sends the second command.
j The Other Device processes the response. That is why it fails to send the second command in time. The Other Device has to wait for next access window.
k The Other Device sends a request to read back the results of last transmitted command.
l When the Meter provides access, the Other Device sends the command to the Meter.
m The Other Device has a new command. It tries to contact the Meter immediately.

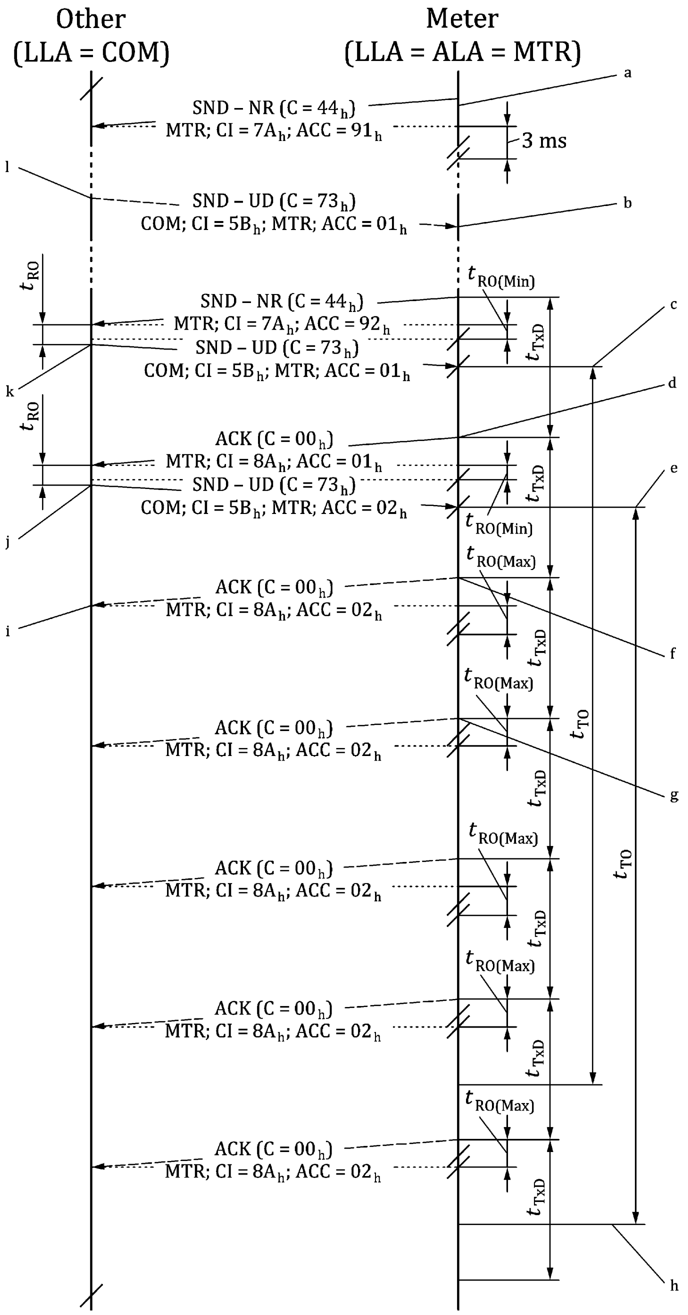
Figure E.3 — Connection applying long transport layer



Key

a A short reception windows follows after every transmission (if Bit B = 1 and Bit A = 0 in Configuration Field).
b Since the receiver is not always open, the message is not received.
c The message was received now. An acknowledge is responded with a predefined delay.
d The Meter generates a response after the predefined delay.
e The Meter misses the next transmission and repeats the last message again after the predefined delay.
f The Meter now receives a new command and generates acknowledge after the predefined delay.
g The Meter receives a SND-NKE (means “End of Transmission”). It stops the frequent access cycle.
h The Other Device receives the acknowledge and finishes the session.
i When the Meter allows the access then Other Device sends the second command.
j The Other Device processes the response. That is why it fails to send the second command in time. The Other Device has to wait for next access window.
k The Other Device sends a request to read back the results of last transmitted command.
l When the Meter provides access, the Other Device sends the command to Meter.
m The Other Device has a new command. It tries to contact the Meter immediately.

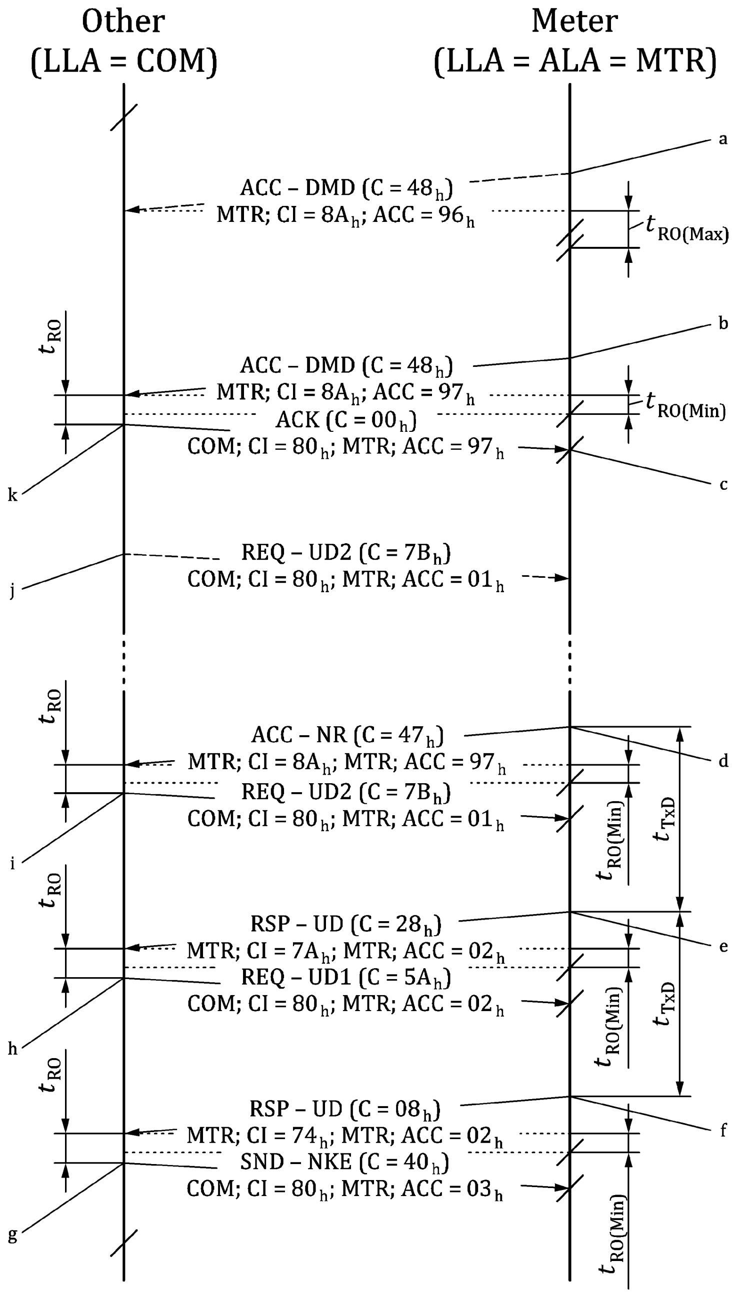
Figure E.4 — Connection applying short transport layer



Key

a A short reception windows follows after every transmission (if Bit B = 1 and Bit A = 0 in Configuration Field).
b Since the receiver is not always open, the message is not received.
c The Meter receives the first message from the Other Device successfully. A Connection-timeout is started.
d After the predefined delay the Meter sends the acknowledge with no. 1 as answer to the command with no. 1.
e The Meter receives a second message from the Other Device successfully. The Connection-timeout is restarted again.
f After the predefined delay the meter sends acknowledge with no. 2 for the first time.
g If no further message from the Other Device is received, then the Meter repeats the last transmission periodically until connection timeout happens (end of frequent access cycle).
h The Meter stops the message repetition by timeout!
i The Other Device stops the communication for some reason.
j The Other Device sends the next command to the Meter.
k When the meter provides access the Other Device sends the command to Meter.
l The Other Device has a new command. It tries to contact the Meter immediately.

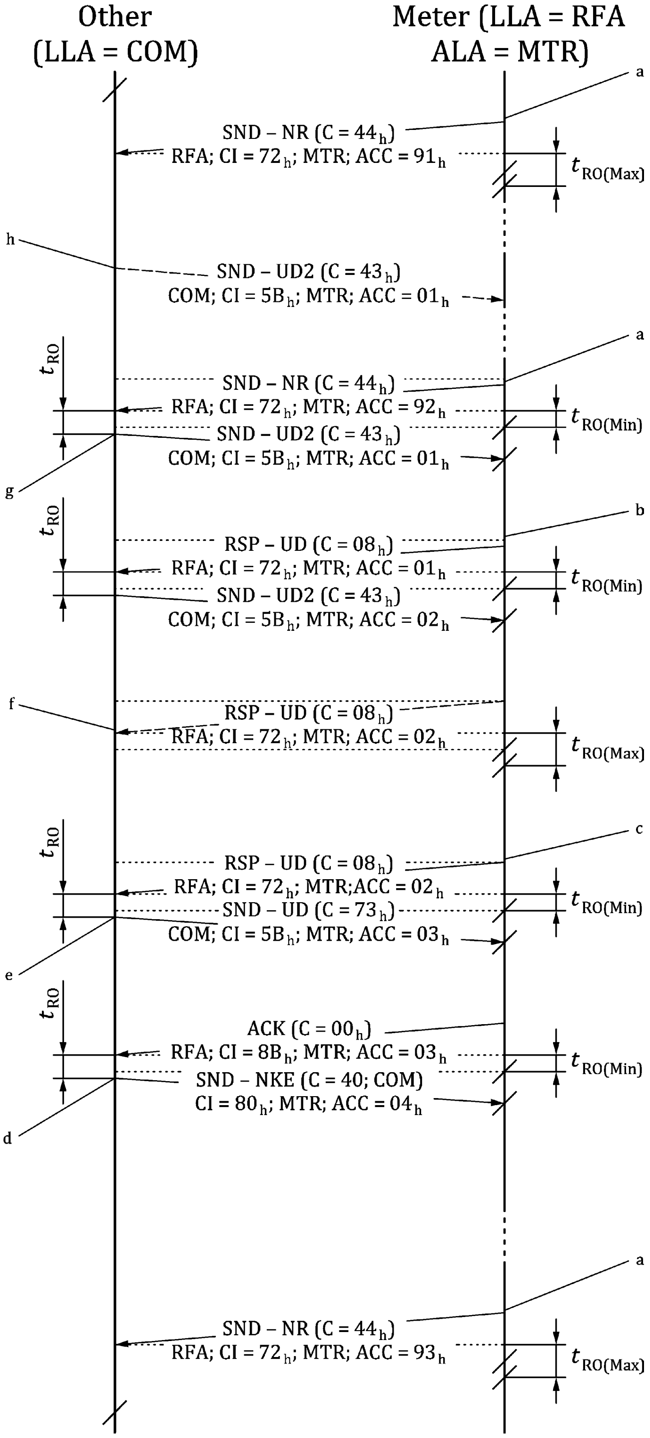
Figure E.5 — Time out, Frequent Access Cycle



Key

a The Meter has an alert and intend to inform the operator. It generates an access demand.
b The Meter repeats the access demand until the Other Device acknowledges it.
c The Meter stops the transmission of the access demand.
d The Meter may accelerate the access by sending an a-periodic transmission.
e The Meter provides status and normal consumption data. In this example an additionally set ACD-bit in the C-field informs the Other Device about available Alarm data (Class 1).
f The Meter responds with an Alarm message. A clear ACD-bit signals there are no more Alarm data available.
g The Other Device finishes the communication.
h Triggered by the ACD-bit the Other Device will request the alarm data (Class 1) with the next unsolicited transmission of the Meter.
i By the next unsolicited transmission of the Meter the Other Device requests the status data (Class 2). It may also ask for alarm data immediately!
j The Other Device may try to read status of the Meter immediately.
k The Other Device acknowledges that access demand was received and that it will be handled soon.

Figure E.6 — Access demand



Key

a Periodic transmission by the Meter

b The Meter answer directly with expected response instead of an ACK.

c The Meter repeats the last message within the FAC.

d If the Other Device finish all transaction it closes the Link using a SND-NKE.

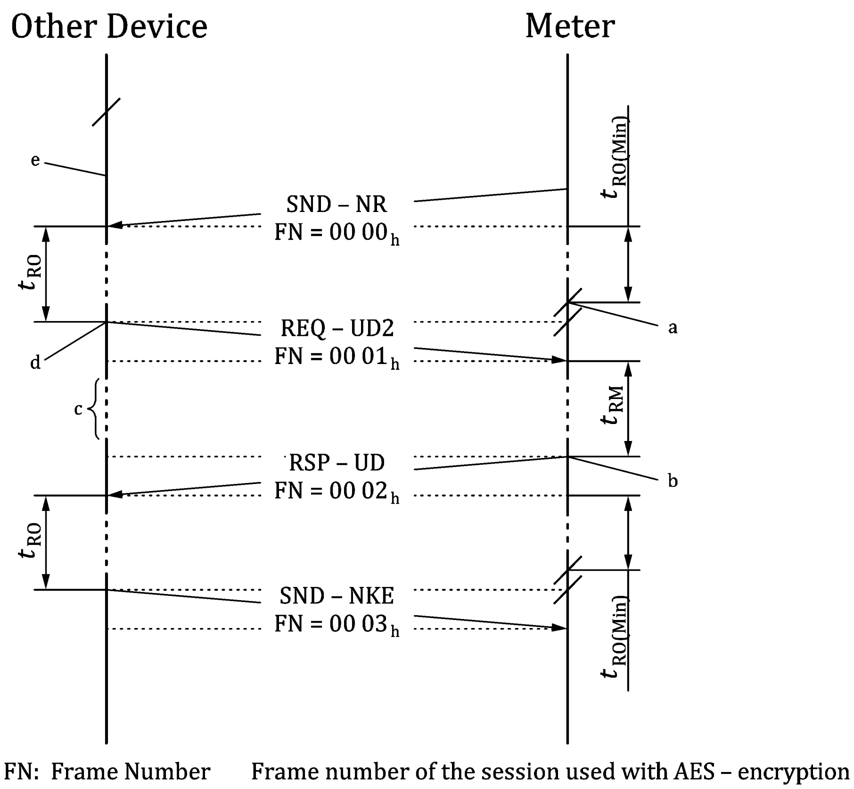
e After the reception of the outstanding response the Other Device continues with next command (here applying a SND-UD, which has to be responded with an simple ACK only).

f The second response was not received, for any reasons.

g The Other Device send a command and expected immediately a response. For that reason it applies a SND-UD2.

h The Other Device may try to contact the Meter if it has no information about the accessibility of the Meter.

Figure E.7 — RF-connection using SND-UD2



Key

a “Meter” switches receiver on and listens after a delay ($t_{RO(Min)}$)

b “Meter” responds after a delay (t_{RM})

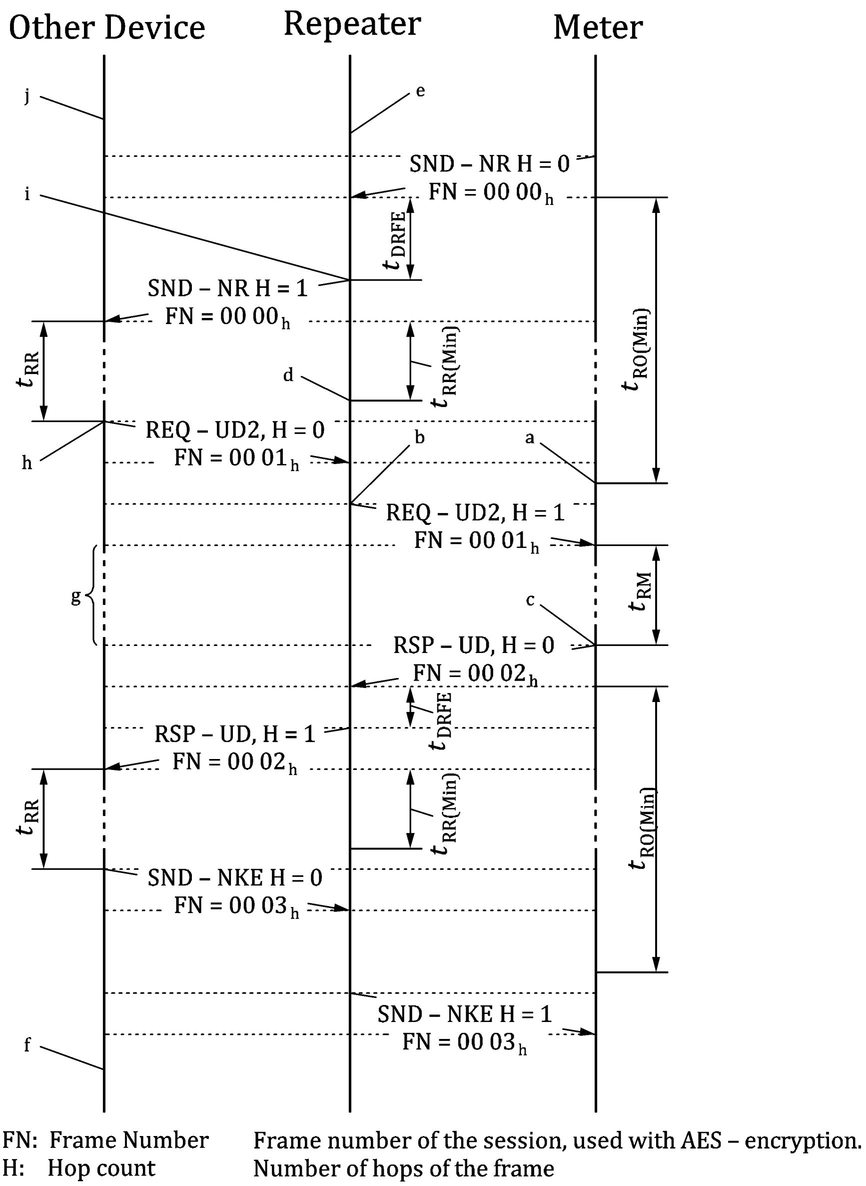
c Time gap

d “Other Device” responds after a delay (t_{RO})

e “Other Device” has the receiver continuously open

Figure E.8 — Mode C, normal transfer

Figure E.9 below emphasizes how the frame number will vary when encryption using AES is performed at the Data Link Layer.



Key

a “Meter” listens after a delay ($t_{RO(Min)}$).

b “Repeater” switches receiver off when response from “Other Device” has been received.

c “Meter” responds after a delay (t_{RM}).

d “Repeater” listens after a delay ($t_{RR(Min)}$).

e “Repeater” listens ahead of meter transmission

f “Other Device” switches receiver off.

g Time gap

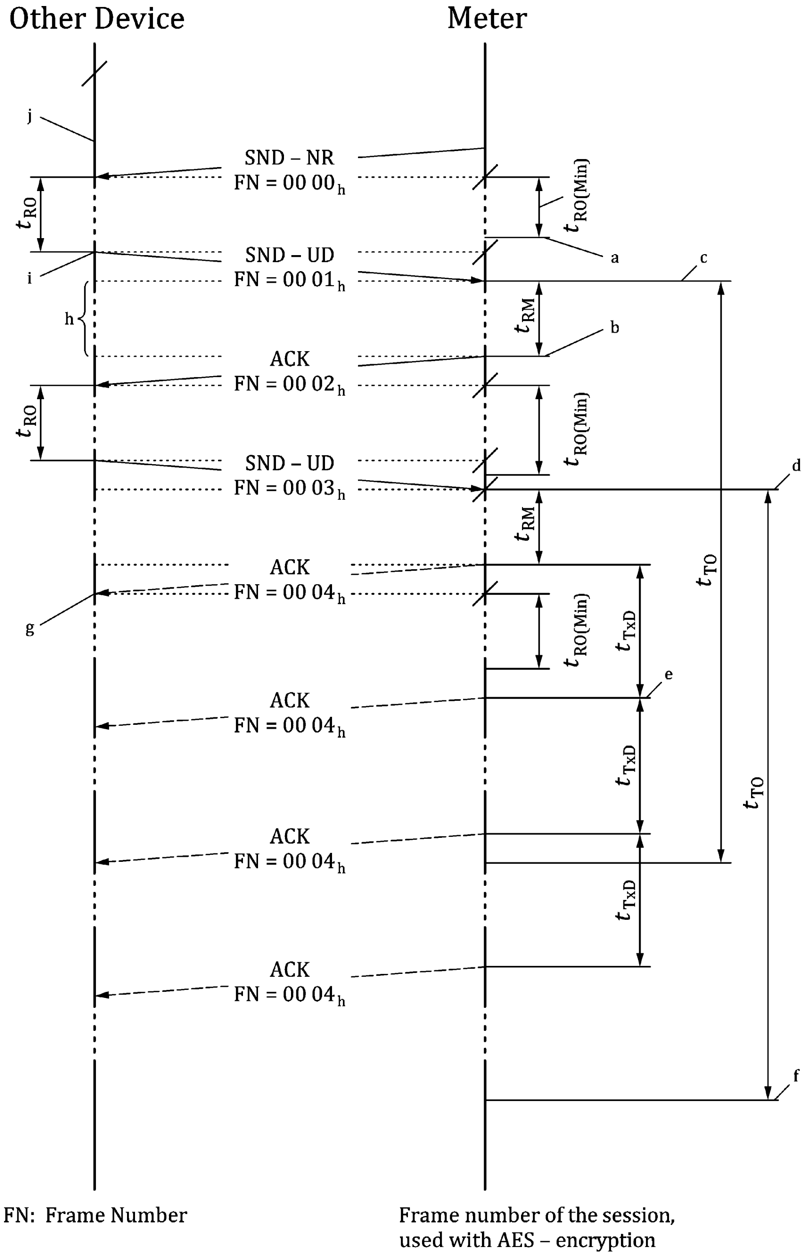
h “Other Device” responds to “Repeater” after a delay (t_{RR}).

i “Repeater” transmits to “Other Device” after a delay (t_{DRFE}).

j “Other Device” has the receiver continuously open.

Figure E.9 — Mode C, transfer involving repeater

Figure E.10 below emphasizes how the parameters Frame number (FN) and Repeated (R) will vary when data transfer with repeating is performed.



Key

a “Meter” listens after a delay ($t_{RO(Min)}$).

b “Meter” responds after a delay (t_{RM}).

c Frame received from “Other Device” – connection timeout (t_{TO}) is started.

d Frame received from “Other Device”, Meter switches receiver off – connection timeout is restarted.

e Frame was not received from “Other Device” and the last frame from “Meter” is repeated after a delay (t_{TxD}).

f “Meter” stops the repetition after a timeout (t_{TO}).

g “Other Device” stops the communication for some reason.

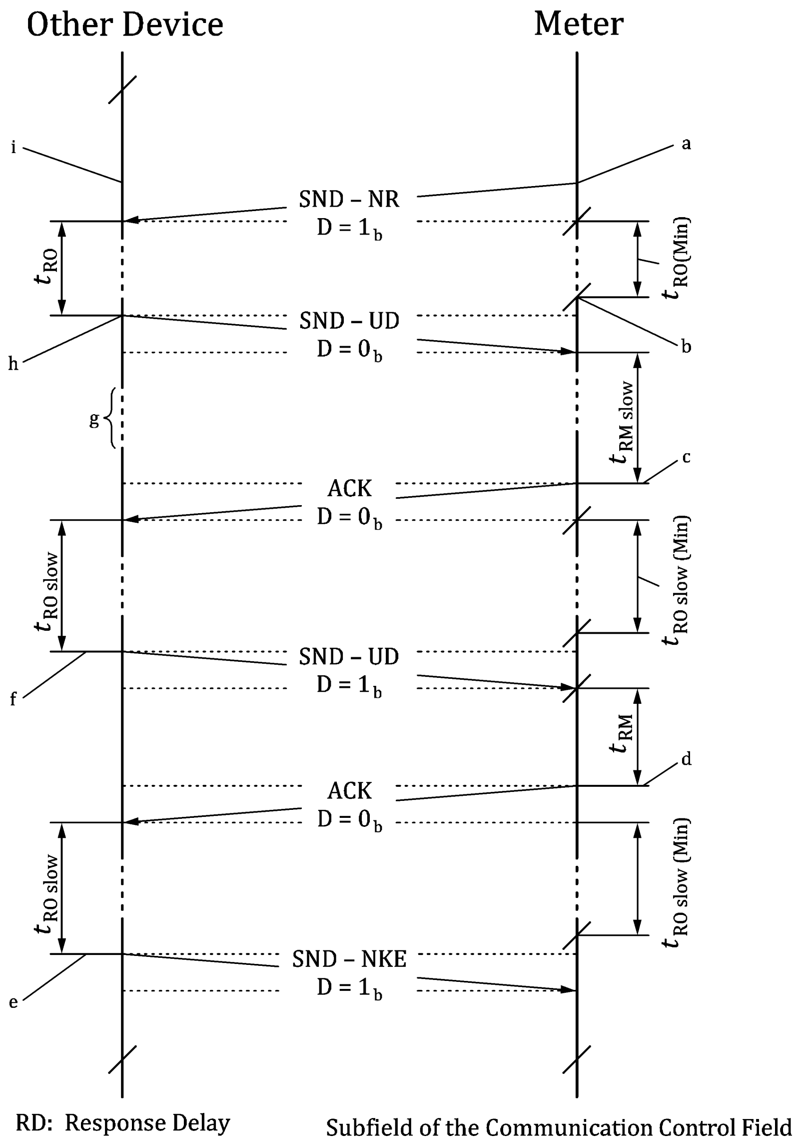
h Time gap

i “Other Device” responds after a delay (t_{RO}).

j “Other Device” has the receiver continuously open.

Figure E.10 — Mode C, using Frequent Access Cycle

Figure E.11 below emphasizes how the Frame number (FN) will vary when using the Frequent Access Cycle protocol.



Key

a “Meter” transmits a frame specifying fast timing (D = 1).

b “Meter” listens after a default delay ($t_{RO(Min)}$).

c “Meter” responds after a slow delay ($t_{RM\ slow}$) since D = 0 in the received frame. When “Meter” receives a frame with D = 0 it shall also use D = 0 in the next frame.

d “Meter” responds after a fast delay (t_{RM}) since D = 1 in the received frame. When “meter” receives a frame with D = 1 it is free to specify fast or slow timing.

e “Other Device” responds after a slow delay ($t_{RO\ slow}$) since D = 0 in the received frame.

f “Other Device” responds after a slow delay ($t_{RO\ slow}$) since D = 0 in the received frame. “Other Device” is always free to specify fast or slow timing.

g Time gap

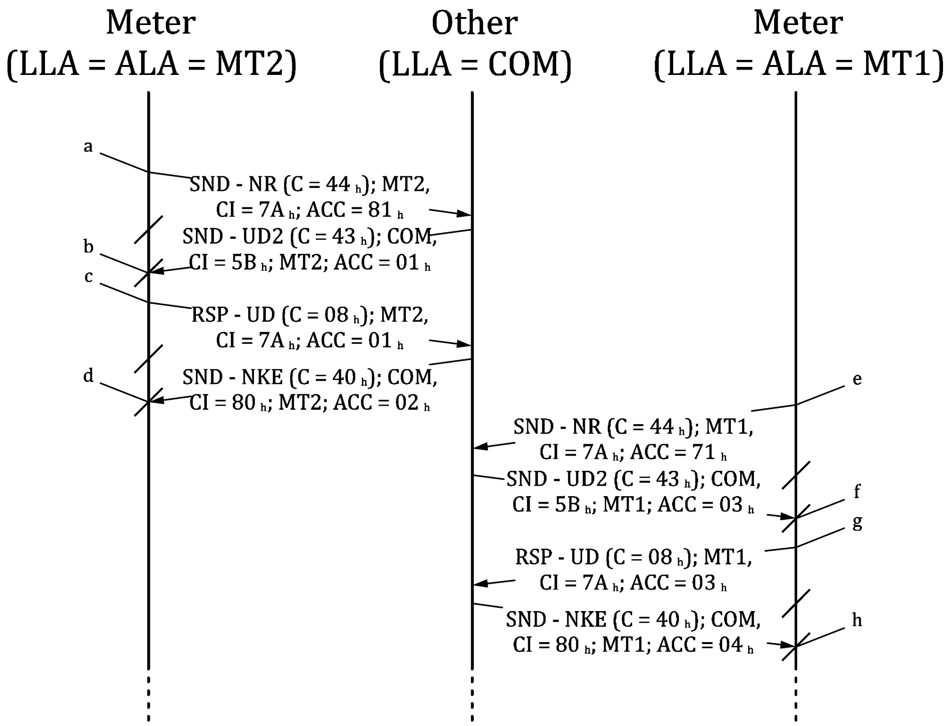
h “Other Device” responds after a fast delay (t_{RO}) since D = 1 in the received frame.

i “Other Device” has the receiver continuously open.

Figure E.11 — Mode C, fast or slow response delay

The diagram that follows shows an example of the use of the SND-UD3 command as applied when performing “Image Transfer” as specified in EN 13757-3:2018 Annex I. It is intended for use when performing multi-cast or broadcast from the “Other Device”. Here data are distributed to a large number of Meters without handshake. The diagrams exemplify the use of SND-UD3 by applying it to a situation of multicast of information.

The Meters are, prior to the multi-cast transfer, individually addressed from the Other Device with a “Prepare” command. This command has included the time to the start of multi-cast and the pace of the multicast. The command is detailed in EN 13757-3:2018, I.2.4. Figure E12 below shows two steps of this flow that is repeated until all Meters has been prepared.



Key

a “Meter”, MT2, transmits normal data frame using SND-NR.

b “Other” responds within MT2’s receive window with a “Prepare” command using SND-UD2 containing parameters for the download session.

c “Meter”, MT2, responds with a “Prepare” response using RSP-UD with status and acceptance.

d “Other” closes session with SND-NKE.

e Another “Meter”, MT1, transmits normal data frame, SND-NR.

f “Other” sends the “Prepare” command to it as well, using SND-UD2.

g “Meter”, MT1, responds with a “Prepare” response using RSP-UD containing status and acceptance.

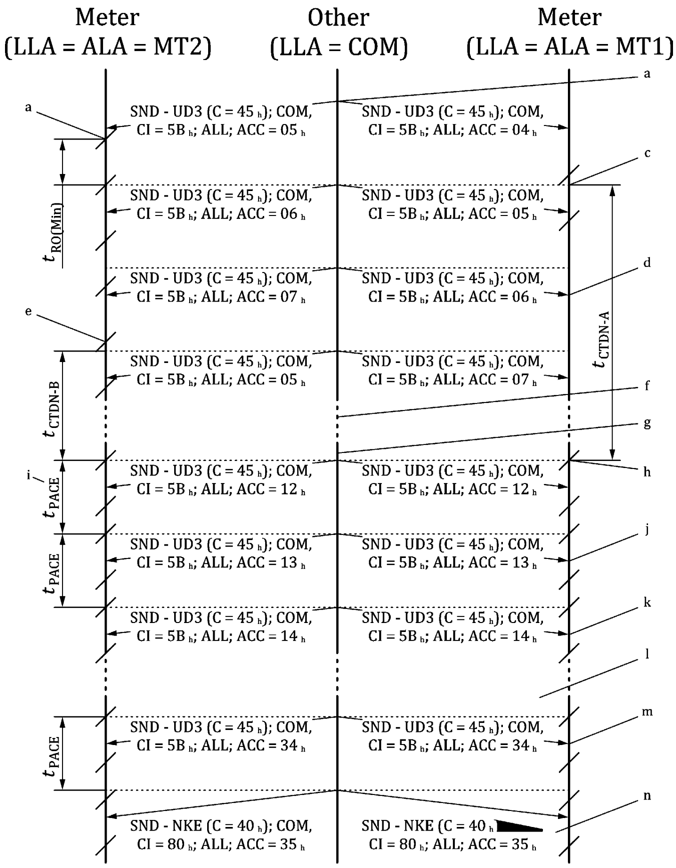
h “Other” closes session with SND-NKE.

Figure E.12 — Preparation for multicast

The Other device will in a period prior to the actual transfer, send a burst of “Synchronize” commands with short time-gap. Each command will hold the current ‘countdown’ time to the start of data transfer. The command is detailed in EN 13757-3:2018, I.2.6. Meters with precise clock may bypass detecting the synchronize messages and only enable the receiver once the actual transfer takes place. Other Meters will need to synchronize. They will have to open their receivers listening window for an extended period to fetch the synchronize message.

The Other device will, when the countdown reaches zero start to transmit data using the “Transfer” command with the previous distributed pace. The format of the command is detailed in EN 13757-3:2018, I.2.7. The Other Device will terminate the transaction with a SND-NKE message.

Figure E.13 below covers the “transfer synchronization” and “transfer of image” phases. It show two meters, MT1 and MT2, with a slightly different behaviour. A thick vertical timeline for the meters indicate when they are in their ‘listening window’.



Key

a "Other" starts the broadcast of a "Synchronize" command. The message contains a countdown value t_{CTDN}, the time until the first information broadcast.

b "Meter", MT2, opens a receive window based on a previously received "Prepare" command but opens the receiver too early and misses the "Synchronize" command.

c "Meter", MT1, opens the receiver at the expected time, based on a previously received "Prepare" command, and receives the "Synchronize" command. "Meter", MT1, is now synchronized, and will from now on not open its receiver before the Image Transfer phase begins. How long to wait is determined by the actual count-down value, $t_{\mathrm{CTDN\text{-}A}}$, received in the "Synchronize" command.

d "Other" broadcasts another Synchronize command, now ignored by "Meter", MT1. It is still outside the receive window of "Meter", MT2, which will have to try at least one more time.

e "Meter", MT2, now opens the receiver such that it is able to receive the "Synchronize" command. "Meter", MT2, is now synchronized, and will from now on not open its receiver before the Image Transfer phase begins. How long to wait is determined by the actual count-down value, $t_{\mathrm{CTDN\text{-}B}}$, received in the "Synchronize" command.

f The above sequence continues while within the Transfer Synchronization phase.

g The count-down is now 0. "Other" starts the transfer by broadcasting the first "Transfer" command.

h The reception windows of the meters, MT1 and MT2, are synchronized, and both meters receive the "Transfer" command.

i Transmission of "Transfer" commands continues with a period of t_{PACE}. The value of t_{PACE} was distributed previously using the "Prepare" command.

j One of the intended receivers does not receive the broadcasted "Transfer" command. The meter will register that the frame is missing. It will continue to try to receive any following frames. It will not start to respond with an error or terminate the transfer.

k This continues while within the Image Transfer phase

l "Other" transmits the last "Transfer" command.

m "Other" broadcasts one or more SND-NKE commands to terminate the multicast transfer. Reception of SND-NKE command(s) indicates to the meters that the Image Transfer phase is over.

Figure E.13 — Multicast synchronization and transfer using SND-UD3

Annex F
(informative)

Counter Mode Flow

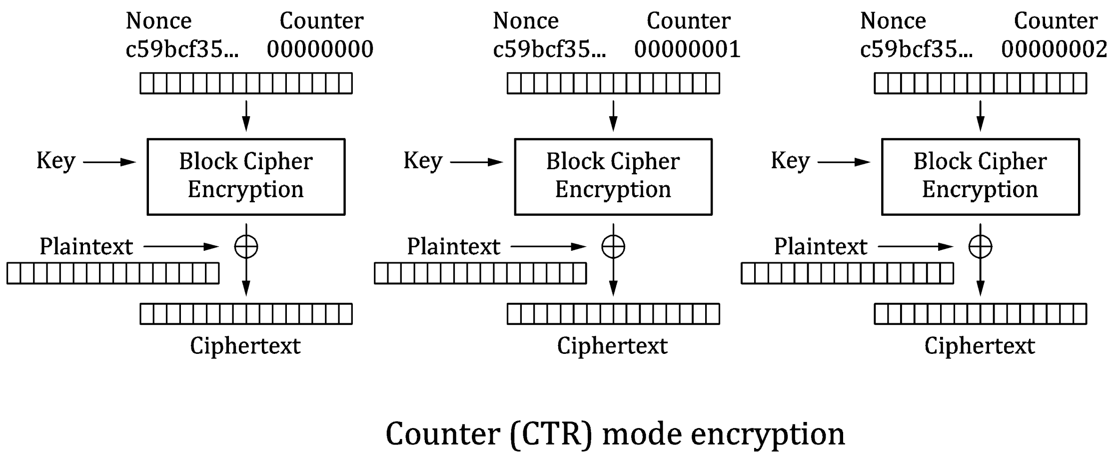


Figure F.1 — AES (128) counter mode encryption flow

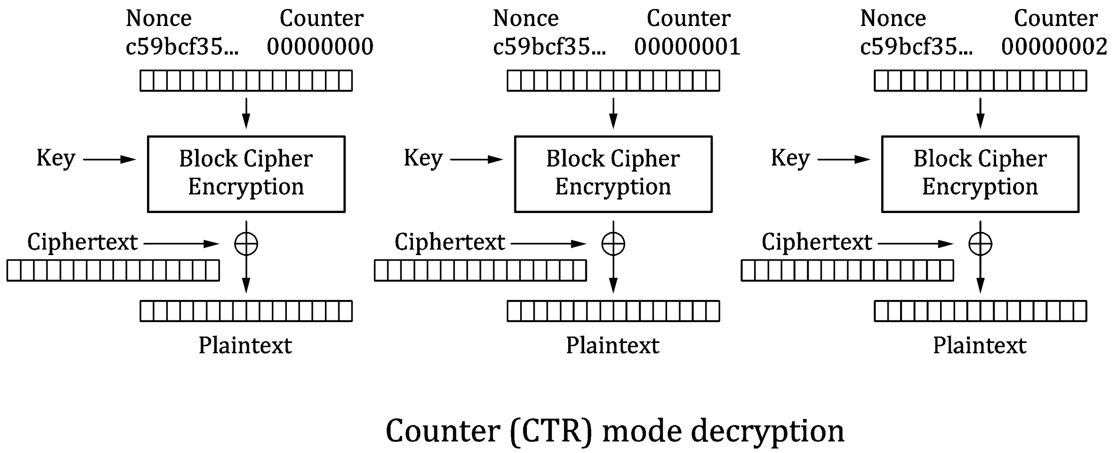


Figure F.2 — AES (128) counter mode decryption flow

Bibliography

[1] EN 13757-6, *Communication systems for meters - Part 6: Local Bus*

[2] CEN-CLC-ETSI/TR 50572, *Functional Reference Architecture for Communications in Smart Metering Systems*

[3] CEN/TR 17167:2018, *Communication system for meters - Accompanying TR to EN 13757-2,-3 and -7, Examples and supplementary information*

[4] EN 62056-53, *Electricity metering — Data exchange for meter reading, tariff and load control — Part 53: COSEM application layer (IEC 62056-53)*

[5] ISO/IEC 18033-3, *Information technology — Security techniques — Encryption algorithms — Part 3: Block ciphers*

[6] *Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity*

[7] *2013/752/EU: Commission Implementing Decision of 11 December 2013 amending Decision 2006/771/EC on harmonisation of the radio spectrum for use by short-range devices and repealing Decision 2005/928/EC (notified under document C(2013) 8776)*

[8] ITU-T Rec. O.150 *(05/96), General requirements for instrumentation for performance measurements on digital transmission equipment*

[9] NIST SP 800-38A, *Recommendation for Block Cipher Modes of Operation: Methods and Techniques, December 2001*

[10] Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC Text with EEA relevance