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ICS

English version

Communication systems for meters and remote reading of meters - Part 4: Wireless meter readout (Radio Meter reading for operation in the 868-870 MHz SRD band)

Systèmes de communication et de télérelevé de compteurs - Partie 4: Echange de données des compteurs par radio (Lecture de compteurs dans la bande SRD 868-870 MHz)

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 294.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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Introduction

The "Meters" may communicate with "Other" system components, for example mobile readout devices, stationary receivers, data collectors or system network components. 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 like 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.

Three different modes of operation are defined for the communication with the meter. Many of the physical and link layer parameters of these different modes of this standard 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 :

a) "stationary mode", mode S. is intended for unidirectional or bi-directional communications between stationary or mobile devices. A special transmit only sub-mode S1 could be optimised for stationary battery operated devices with a long header and the sub-mode S1-m is specialised for mobile receivers ;

b) "frequent transmit mode", mode T. In this mode, the meter transmits a very short telegram (typically 2-5 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 or stochastically.

   The bi-directional sub-mode T2 transmits frequently a short telegram containing at least its ID and then waits for a very short period after each transmit for the reception of an acknowledge. Reception of an acknowledge will open a bi-directional communication channel.

c) "Frequent receive mode", mode R2. In this mode, 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 dialog with the initiating transceiver. In this mode a “multi-channel receive mode” allows the simultaneous readout of several meters, each one operating inside a different frequency channel.

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

Foreword

This document (prEN 13757-4) has been prepared by Technical Committee CEN/TC 294 “Communication systems for meters and remote reading of meters”, the secretariat of which is held by AFNOR.

This document is currently submitted to the CEN Enquiry.

1 Scope

This standard defines the requirements of parameters for the physical and the link layer for systems using radio to read remote meter. The primary focus is in using the Short Range Devices (SRD) unlicensed telemetry band, 868 to 870 MHz. The standard encompasses systems for walk-by, drive-by and fixed installations. As a broad definition, It can be applied to various application layers.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

IEC 60870-5-1:1990, *Telecontrol equipment and systems – Part 5 : Transmission protocols – Section 1 : Transmission frame format*.

IEC 60870-5-2:1992, *Telecontrol equipment and systems – Part 5 : Transmission protocols – Section 2 : Link transmission procedures.*

IEC 62056-53:2002, *Electricity metering – Data exchange for meter reading, tariff and load control – Part 53 : COSEM Application Layer*.

EN 300220-1 V.1.3.1:2000-09, section 9.1, 9.2 and 9.3, *Electromagnetic compatibility and Radio spectrum Matters (ERM) ; Short Range Devices (SRD) ; Radio equipment to be used in the 25 MHz to 1 000 MHz frequency range with power levels ranging up to 500 mW – Part 1 : Technical characteristics and test methods.*

EN 300220-2 V.1.3.1:2000-09, section 9.1, 9.2 and 9.3, *Electromagnetic compatibility and Radio spectrum Matters (ERM) ; Short Range Devices (SRD) ; Radio equipment to be used in the 25 MHz to 1 000 MHz frequency range with power levels ranging up to 500 mW – Part 2 : Supplementary parameters not intended for conformity purposes.*

EN 301489-1 V.1.2.1:2000-8, section 9.2 and 9.3, *Electromagnetic compatibility and Radio spectrum Matters (ERM) ; ElectroMagnetic Compatibility (EMC) standard for radio equipment and services –Part 1 : Common technical requirements*.

EN 301489-3 V.1.2.1:2000-8, section 9.2 and 9.3, *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 40 GHz*.

CEPT/ERC Recommandation 70-03 E, *Relating to the use of Short Range Devices (SRD)*.

EN 1434-3:1997, *Heat meters – Part 3 : Data exchange and interfaces*.

prEN 13757-3, *Communication systems for meters and remote reading of meters – Part 3 : Dedicated application layer (M-Bus)*.

3 Terms and definitions

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

3.1
meter communication types
the following table describes the key features of each mode and sub-mode

Tableau 1 — Meter communication type

Mode	WAY	Typical Application	Chip-rate kcs	Duty cycle Note 1	Maximum duty cycle Note 2	Data coding + Header	Description
S1	1	Transmit only meter for stationary receiving readout	32,768	1 %	0,02 %	Manchester + 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 economised receiver.
S1-m	1	Transmit only meter for mobile or stationary readout	32,768	1 %	0,02 %	Manchester + short header	Transmit only; transmits with a duty cycle limitation of 0,02 % per hour to a mobile or stationary receiving point. Transmits in the 1 % duty cycle frequency band. Requires a continuously enabled receiver.
S2	2	All meter types. Stationary reading	32,768	1 %		Manchester + short header or option long header	Meter unit with a receiver either continuously enabled or synchronised requiring no extended preamble for wakeup. Also usable for node transponders or concentrators. A long header is optional.
T1	1	Frequent transmission (short telegram meters)	100	0,1 %		3 to 6 / + short header	Transmit only with short data bursts < 5 ms every few seconds, operates in the 0,1 % duty cycle frequency band.
T2	2	Frequent transmission (Short telegram meter with 2 way capability)	Meter : Tx : 100 Meter Rx : 32,768	0,1 % 1 %		3 to 6 + Short header Manchester + 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 acknowledge (at 32,768 kcps) is received. Further bi-directional communication in the 0,1 %-frequency band using 100 kcps (meter transmit) and 32,768 kcps (meter receive) may follow. Note that the communication from the meter to the "other" component uses the physical layer of the T1 mode, while the physical layer parameters for the reverse direction are identical to the S2-mode.
R2	2	Frequent reception (long range)	4,8	1 %		Manchester + Medium header	Meter receiver with possible battery economiser, requiring extended preamble for wake-up. Optionally, it may have up to 10 frequency channels with a high precision frequency division multiplexing . Meter response with 4,8 kcps wake-up followed by a 4,8 kcps header.
All		Multi-mode option					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

NOTE 1 The duty cycle limitation shall conform to the frequency band allocation defined for operation in the 868-870 MHz SRD bands according to CEPT/ERC Recommendation 70-03 E.

NOTE 2 The duty cycle per meter is limited to 0,02 % per hour to limit the total occupancy of the channel up to 10 % with 500 meters installed within transmission range.

The following drawing illustrates the operation between the different modes and components.

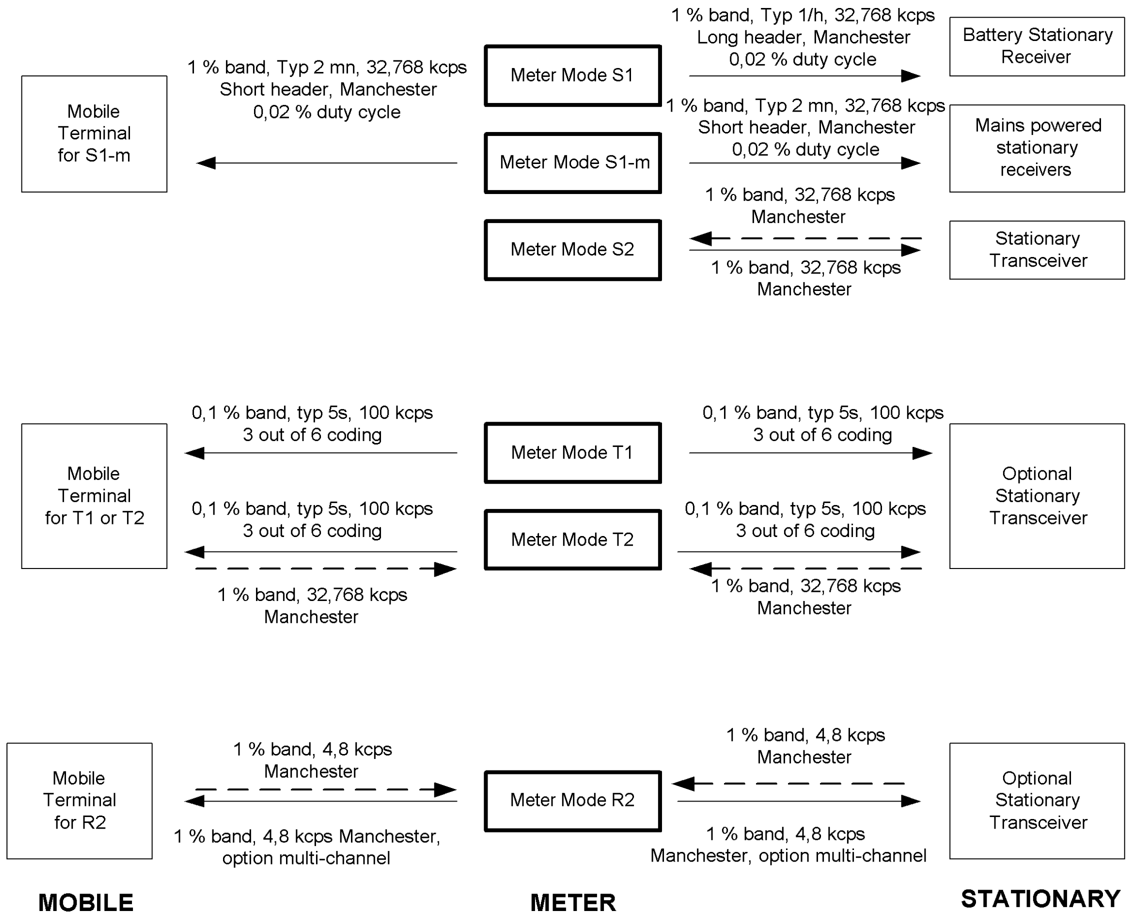

Figure 1 — Meter communication types

3.2
performance classes
the transmitters can be one of three classes levels ranging from low, medium to the high radiated power
the maximum allowable radiated power for the transmitter is defined by ERC 70-03E or as permitted by local radio regulation

When existing, the receiver too will range in sensitivity and blocking performances, from low to high.

It is possible to mixed the performance for the transmitter and the receiver.

Description of performances – the class of receivers and transmitters defines power, sensitivity and selectivity.

The transmission power is measured as the effective radiated power (ERP) according to § 8.3 of EN 300220-1.

The maximum usable sensitivity is measured in conducted mode according to § 4.1 of EN 300220-2. In addition, the manufacturer shall give the antenna gain, which shall be measured according to ANSI C63.5.

Table 2 — Performance classes

Transmitter Class	**Typical Application**	**Description**	**Minimum ERP P_{erp}**	
L_T	Lowest performance	Limited RF power	-5 dBm	
M_T	Medium performance	Medium transmission power	0 dBm	
H_T	Highest performance	Highest transmission power	meter to other +5 dBm other to meter +8 dBm	
Receiver Class	**Typical Application**	**Description**	**Maximum usable sensitivity (conducted measurement) at BER 10^{-2} or block acceptance rate > 80 % P_0 see note 1 and note 2**	**Antenna gain dBi G_a**
L_R	Lowest performance	Limited sensitivity, minimum blocking performances	- 80 dBm	note 3
M_R	Medium performance	Medium sensitivity, good blocking performances	- 90 dBm	note 3
H_R	Highest performance	Best sensitivity and best blocking performances	see modes § 4.3, § 5.3, § 6.3	note 3

NOTE 1 For practical reason, the sensitivity is measured in conducted mode according to § 4.1 of EN 300220-2. But for the user, an important parameter is the radiated sensitivity, which could be estimated by combining the conducted sensitivity and the antenna gain..

NOTE 2 If the conducted mode is not possible, the sensitivity shall be measured by sending known field strength to the receiver, according to § 4.2 of EN 300220-2. Then the radiated sensitivity could be measured via the block acceptance rate.

NOTE 3 The value of the antenna gain shall be given by the manufacturer inside the technical documentation.

4 Mode S

4.1 Mode S : General

All the parameters as a minimum shall conform to the requirements of EN 300220, even if some application requires extended temperature or voltage range.

Table 3 — Mode S, general

Characteristics	Min	Typical	Max.	Unit	Note
Frequency band	868,0	868,3	868,6	MHz	(1)
Transmitter duty cycle S2			1	%	(2)
Transmitter duty cycle S1 & S1-ml			0,02	%	(2)

NOTE 1 The standard is optimised for the 868-870 MHz band (see the graphic in annex A), although with an appropriate transmission licence, other frequency bands could be used, i.e. 433 MHz.

NOTE 2 Measuring the duty cycle as defined by EN 300220-1.

4.2 Mode S : Transmitter

The parameters for the transmitters are there below.

Table 4 — Mode S, transmitter

Characteristic	Mode	Sym	Min	Typ	Max	Unit	Note
Centre frequency (transmit only meter, S1-submode)			868,25	868,30	868,35	MHz	~60ppm
Centre frequency (other and S2-mode)			868,278	868,300	868,322	MHz	~25ppm
FSK Deviation			+/-40	+/-50	+/-80	kHz	
Chip rate transmit		f_{chip}		32,768		kcps	
Chip rate tolerance			-1,5	0	+1,5	%	
Digital bit jitter					+/-3	us	(1)
Data rate (Manchester)				f_{chip} *1/2		bps	(2)
Preamble length including bit/byte-sync, both directions	S2, S1-M		48			chips	
Preamble length including bit/byte-sync	S1		576			chips	Optional for S2
Postamble (trailer) length			2		8	chips	(3)
Response delay		t_{RO}	3		50	ms	(4)

NOTE 1 The bit jitter is measured at the output of the micro-controller or encoder circuit.

NOTE 2 Each bit is coded as 2 chips (Manchester coding).

NOTE 3 The postamble (trailer) consists of n = 1 to 4 "ones" i.e. the chip sequence is n*(01).

NOTE 4 Response delay : after transmitting a telegram in the S2-mode, the receiver must be ready for the reception of a response in a time shorter than the minimum response delay, and must be receiving for the duration of the maximum answer delay.

4.3 Mode S : Receiver

Table 5 — Mode S, receiver

Characteristic	Class	Symb	Min	Typ	Max	Unit	Note
Sensitivity (BER 1 in 10^2) or block acceptance rate > 80 %	H_R	P_o	-100	-105		dBm	
Blocking performance	L_R		3			Class	(1)
Blocking performance	M_R		2			Class	(1) (3)
Blocking performance	H_R		2			Class	(1),(2) (3)
Acceptable Chip rate tolerance		Df_{chip}	-2	0	2	%	
Chip rate (meter)		f_{chip}		32,768		kcps	

NOTE 1 Receiver class according to EN 300220-1, section 9.3.

NOTE 2 Additional requirement for H_R – class receivers : Blocking the adjacent band : rejection of 40 dB minimum, according to EN 300220-1, section 9.1 and 9.2 respectively.

NOTE 3 Additional requirement for M_R – H_R receiver class : Immunity test against radio frequency electromagnetic field according to EN 301489-1, section 9.2 and EN 301489–3.

4.4 Mode S : Data encoding

4.4.1 Mode S : Manchester encoding

Manchester encoding is defined for this mode to allow simple coding/decoding and occupy a narrower base-band. Each bit is encoded as either "10" chip sequence representing a "zero" or as a "01" representing a "one".

4.4.1.1 Mode S : Order of transmission of the encoded data

Each data byte is transmitted with the most significant bit (MSb = Most significant bit) first.

The byte sequence of the CRC is high byte first. The byte sequence of the manufacturer field is low byte first. The byte sequence of other multi-byte field is not defined in this standard, however it is recommended that the low byte be first.

The lower frequency corresponds to a chip value of "0".

4.4.1.2 Mode S : Preamble chip sequences

The total preamble (header + synchronisation) chip sequence for this mode is n*(01) 0001110110 10010110 :

with n ≥ 279 for the sub-mode S1 (long header) ;

with n ≥ 15 for the sub-mode S2 (short header) ;

with n ≥ 279 for the sub-mode S2 optional long header.

NOTE 1 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 telegram and an accidental "sync" sequences within an ongoing transmission.

NOTE 2 The data encoding is identical to Mode R2.

4.5 Mode S : Data link layer

The link layer of IEC 60870-5-2 with the format class FT3 is used. All chips of each telegram must form a gap-less chip sequence.

4.5.1 Mode S : Frame format

The general format of the frame is the following.

4.5.1.1 Mode S : First Block

Table 6 — Mode S, frame format

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

Table 7 — Mode S, optional second block

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

4.5.1.2 Mode S : Optional other block

Table 8 — Mode S, optional other block

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

4.5.2 Mode S : Field definition

Mode S The fields are defined in IEC 60870-5-2 as follow.

4.5.2.1 Mode S : L : Length field

The first byte of the first block is the length field (L = 0 to 255), which signals the total number of user bytes (excluding the length field and the CRC’s). If ((L-9) MOD 16) is not zero, the last block contains ((L-9) MOD 16) data bytes + 2 CRC bytes. All the other blocks contain always 16 data bytes + 2 CRC bytes.

4.5.2.2 Mode S : C : Control Field

The second byte is the C-field, which signals the telegram type. According to IEC 60870-5-2 the following C-field codes are used :

- for the transmit only sub-mode S1 the C-field value C=44 $_h$ (send-no-Reply) is used ;
- if the meter is in the installation mode, the C-field value C=46 $_h$ is used to signal this mode ;
- for the sub-mode S2 all C-field values of IEC 60870-5-2 may be used.

4.5.2.3 Mode S : M : Manufacturer ID

Bytes 3 and 4 of the first block contain 2 bytes for a unique user/manufacturer ID of the meter. It is formed from an ASCII-three letter code (A..Z) according to EN 1434-3 (see annex B for administration). These two bytes are transmitted low byte first.

If the most significant bit of this two bytes unique user/manufacturer ID is equal to zero, the address A is a unique (hard coded) manufacturer meter address of up to 6 bytes. Each manufacturer is responsible for the world-wide 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 bytes code unique user/manufacturer ID is different from zero, the 6-byte address is unique at least within the maximum transmission range of the system (soft address), which is usually assigned to the device at installation time. As long as these unique address requirements are fulfilled, the remaining bytes can be used for user specific purposes.

4.5.2.4 Mode S : A : Address

This address A must be unique (at least within the maximum transmission range). Each user/manufacturer must guarantee that this ID is unique.

4.5.2.5 Mode S : CI : Control Information Field (1 byte)

Located at the beginning of the second block, the CI field indicates the type of protocol and thus the nature of the information which are following. The CI values are

Table 9 — Mode S, CI information field

CI Value	Designation	Remarks
51_h	Data sent by the Readout device to the meter without fixed header to be defined	For compatibility with the future M-Bus application layer standard
71_h	Reserved for alarm report	For compatibility with the future M-Bus application layer standard
72_h	M-Bus Application Layer with full header	For compatibility with the future M-Bus application layer standard
78_h	M-Bus Application Layer without header, to be defined	For compatibility with the future M-Bus application layer standard
$7A_h$	M-Bus Application Layer with short header	For compatibility with the future M-Bus application layer standard
81_h	Relaying Application layer	See chapter 7
82_h	For future use	For compatibility with the future CENELEC TC 205 standard
$A0_h$-$B7_h$	Manufacturer specific Application Layer	

4.5.3 Mode S : CRCx : Cyclic Redundancy Check

The most significant bit is sent first. The CRC is computed over the information from the previous block, and is according to FT3 of IEC 60870-5-1 with the following formula :

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.

Annex C gives an example of the coding of a full message in mode S1 (for information only).

5 Mode T

5.1 Mode T : General

All the parameters at the minimum shall conform to the EN 300220, even if some applications require extended temperature or voltage range.

Table 10 — Mode T, general

Characteristic	Mode	Sym	Min	Typ	Max	Unit	Note
Frequency band : meter to other	T1, T2		868,7	868,95	869,2	MHz	(1)
Frequency band : other to meter	T2		868,0	868,3	868,6	MHz	(1)
Transmitter duty cycle : meter to other	T1, T2				0,1	%	(2)
Transmitter duty cycle : other to meter	T2				1	%	(2)

NOTE 1 The standard is optimised for the 868-870 MHz band, but with local radio approval it may allow operation in other frequency bands, e.g. 433 MHz.

NOTE 2 Duty cycle as defined by EN 300220-1.

See the graphic in annex A.

5.2 Mode T : Transmitter

The parameters for the transmitters are there below.

Table 11 — Mode T, transmitter

Characteristic	Mode	Sym	Min	Typ	Max.	Unit	Note
Centre frequency : (meter to other)	T1, T2		868,90	868,95	869,00	MHz	~60ppm
Centre frequency : (other to meter)	T2		868,278	868,300	868,322	MHz	~25ppm
FSK Deviation : (meter to other)	T1, T2		+/-40	+/-50	+/-80	kHz	
FSK Deviation : (other to meter)	T2		+/-40	+/-50	+/-80	kHz	
Chip rate transmit : (meter to other)	T1, T2	f_{chip}	90	100	110	kcps	
Rate variation within header + telegram : (meter)	T1, T2	Df_{chip}	-1	0	+1	%	
Data rate : meter to other (3 of 6 encoding)	T1, T2			f_{chip} *2/3		bps	(1)
Chip rate transmit : (other to meter)	T2			32,768		kcps	
Chip rate tolerance (other to meter)	T2		-1,5	0	+1,5	%	
Digital bit jitter	T2				3	us	
Data rate other to meter (Manchester)	T2			f_{chip} *1/2		bps	
Preamble length including bit/byte-sync, both directions	T1, T2		48			chips	
Post-amble (trailer) length	T1, T2		2		8	chips	(2)
Acknowledge delay	T2	t_{ACK}	2		3	ms	(3)

NOTE 1 Each nibble coded as 6 chips, see below.

NOTE 2 The postamble (trailer) consists of two alternating chips, i.e. if the last chip of the CRC was a zero, the minimum postamble is a "10", otherwise it's a "01".

NOTE 3 Acknowledge delay : after transmitting a telegram including the post-amble, the receiver must be ready for the reception of an acknowledge. This should include response to the pre-header in a time shorter than the minimum response delay, and must be waiting for the duration of the maximum answer delay, for the start of a possible acknowledge.

5.3 Mode T2 only : Receiver

Table 12 — Mode T2 only, receiver

Characteristic	Mode/ Class	Symb	Min	Typ	Max	Unit	Note
Sensitivity (BER 1 in 10^2)or block acceptance rate > 80 %	H_R	P_o	-100	-105		dBm	
Blocking performance	L_R		3			Class	(1)
Blocking performance	M_R		2			Class	(1) (3)
Blocking performance	H_R		2			Class	(1) (2) (3)
Acceptable header chip rate range : (Other)	T1, T2	f_{chip}	88	100	112	kcps	+/-12 %
Acceptable chip rate variation during header and telegram : (Other)	T1, T2	Df_{chip}	-2	0	+2	%	
Chip rate (meter)	T2	f_{chip}		32,768		kcps	
Acceptable Chip rate tolerance (meter)	T2	Df_{chip}	-2	0	2	%	

NOTE 1 Receiver class according to EN 300220-1, section 9.3.

NOTE 2 Additional Requirement for HR receiver class : blocking adjacent band : rejection of 40 dB minimum, according to EN 300220-1, section 9.1 and 9.2 respectively.

NOTE 3 Additional requirement for M_R - H_R receiver class : immunity test against radio frequency electromagnetic field according to EN 301489-1, section 9.2 and EN 301489-3.

5.4 Mode T : Data encoding

In the mode T1 and T2, for optimum fast transmission, the data going from the meter to the reader device are encoded by the efficient 3 to 6 code. In the mode T2, the reader can send back a message to the meter, which will be encoded by the Manchester code (see § 5.4.2).

5.4.1 Mode T1 and T2 meter transmit : "3 of 6" data encoding (meter to other)

3 of 6 encoding is used for the T mode to give an improved efficiency in comparison with a Manchester encoding. Unique codes are used for specified control functions such as preamble, message start, etc.

Each 4-bit nibble of data is encoded as a 6-bit word and only those words, out of the 64 combinations, with an equal number of zero's and one's, and with a minimum of 2 transitions, have been selected.

Table 13 — Mode T1 and T2 meter transmit, "3 out of 6" data encoding

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

5.4.1.1 Mode T1 and T2 meter transmit : Order of transmission of the encoded data

The data coded as 3 out of 6 are transmitted most significant bit (MSb = Left bit of the 6-bit code) first and with the most significant nibble (MSN) first.

Each data byte is transmitted always with the most significant bit (MSb = Most significant bit) first.

The byte sequence of the CRC is high byte first, the byte sequence of the manufacturer field is low byte first. The byte sequence of other multi-byte field is not defined in this standard, however it is recommended that the low byte is first.

The lower frequency corresponds to a chip value of "0".

5.4.1.2 Mode T1 and T2 meter transmit : Preamble chip sequences

The total preamble (header + synchronisation) chips sequence for this mode is n*(01) 0000111101 with $n \geq 19$.

The chip sequence 0101010101 is allocated to 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. Also, the high number of transitions ensures the best resolution for the clock timing errors. Within the telegram, the maximum number of continuous zeroes or ones is four, but the sequence 00001111 and the sequence 11110000 will never occur inside a telegram.

The chip sequence 0101010101 cannot occur during a normal transmission packet so the decoder can use this to indicate that the receiver has been captured by another transmission ; in that case, the receiver will stop the analysis of the current packet and start a new one. This "capture detect" feature increases the communication capacity of the system in presence of many users.

5.4.2 Mode T2, other transmit : Manchester encoding

Manchester encoding is defined for this mode to allow simple coding/decoding and a narrow base-band. Each bit is encoded either as "10" chip sequence representing a "zero" or as "01" representing a "one".

5.4.2.1 Mode T2, other transmit : Order of transmission of the encoded data

Each data byte is transmitted always with the most significant bit (MSb = Most significant bit) first.

The byte sequence of the CRC is with the high byte first. The byte sequence of the manufacturer field is with the low byte first. The byte sequence of other multi-byte field is not defined in this standard, however it is recommended that the low byte be first.

The lower frequency corresponds to a chip value of "0".

5.4.2.2 Mode T2, other transmit : Preamble chip sequences

The total preamble (header + synchronisation) chip sequence for this mode is n*(01) 0001110110 10010110 with $n \geq 15$.

NOTE 1 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 telegram and an accidental “sync” sequences within an ongoing transmission.

NOTE 2 The data encoding is identical to mode S and R.

5.5 Mode T : Data link layer

The link layer of IEC 60870-5-2 with the format class FT3 is used. All chips of each telegram must form an uninterrupted chip sequence.

5.5.1 Mode T : Frame format

The general format of the frame is the following.

5.5.1.1 Mode T : First Block

Table 14 — Mode T, first block

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

5.5.1.2 Mode T : Optional second block

Table 15 — Mode T, optional second block

CI	Data	CRC
1	15 or ((L-9) modulo 16) if it is the last	2

5.5.1.3 Mode T : Other optional block

Table 16 — Mode T, other optional block

Data	CRC
16 or ((L-9) modulo 16)-1) if it is the last	2

5.5.2 Mode T : Field definitions

The fields are defined in IEC 60870-5-2 as follow :

5.5.2.1 Mode T : L : Length field

The first byte of the first block is the length field (L = 0 to 255), which signals the total number of user bytes (excluding the length field and the CRC's). If ((L-9) MOD 16) is not zero, the last block contains ((L-9) MOD 16) data bytes + 2 CRC bytes. All the other blocks contain always 16 data bytes + 2 CRC bytes.

5.5.2.2 Mode T : C : Control field

The second byte is the C-field, which signals the telegram type. According to IEC 60870-5-2, the following C-field codes are used :

- for the sub-mode T1 (send-no-Reply) the C-field value $C=44_h$ is used ;
- the C-field value $C=46_h$ is used to signal that the meters are in the installation mode ;
- for the sub-mode T2, the meter sends frequently the message "Access demand" ($C=48_h$) and waits for an acknowledge ($C=00_h$) of this request. If the link is established all C-fields of the IEC 60870-5-2 may be used for further communication.

5.5.2.3 Mode T : M : Manufacturer ID

Bytes 3 and 4 of the first block contain 2 bytes for a unique user/manufacturer ID of the meter. It is formed from an ASCII-three letter code (A..Z) according to EN 1434-3 (see annex B for administration). These two bytes are transmitted low byte first.

If the most significant bit of this two bytes unique user/manufacturer ID is equal to zero, the address A is a unique (hard) manufacturer meter address of up to 6 bytes. Each manufacturer is responsible for the world-wide uniqueness of these 6 bytes. He may use any type of coding or numbering, including type/version/date as long as this ID is unique.

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

5.5.2.4 Mode T : A : Address

This address A must be unique (at least within the maximum transmission range). Each user/manufacturer should guarantee that this ID is unique.

5.5.2.5 Mode T : CI Control Information Field (1 byte)

Located at the beginning of the second block, the CI field indicates the type of protocol and thus the nature of the information which are following. The CI value is :

Table 17 — Mode T, CI Control Information Field (1 byte)

Ci value	Designation	Remarks
51_h	Data send by the Readout device to the meter, without fixed header to be defined	For compatibility with the future M-Bus application layer standard
71_h	Reserved for Alarm Report	For compatibility with the future M-Bus application layer standard
72_h	M-Bus Application Layer with full header	For compatibility with the future M-Bus application layer standard
78_h	M-Bus Application Layer without header to be defined	For compatibility with the future M-Bus application layer standard
$7A_h$	M-Bus Application Layer with short Header	For compatibility with the future M-Bus application layer standard
82_h	For future use	For compatibility with future CENELEC TC 205 standard
$A0_h$-$B7_h$	Manufacturer specific Application Layer	

5.5.3 Mode T : CRCx : Cyclic Redundancy Check

The most significant bit is sent first. The CRC is computed over the information from the previous block , and is according to FT3 of IEC 60870-5-1 with the following formula :

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.

Annex D gives an example of the coding of a full message in mode T1 (for information only).

6 Mode R2

6.1 Mode R2 : General

All the parameters at the minimum shall conform to the EN 300220, even if some application requires extended temperature or voltage range.

Table 18 — Mode R2, general

Characteristic	Type	Sym	Min	Typ	Max	Unit	Note
Frequency band			868,0	868,33	868,6	MHz	(1)
Channel spacing				60		kHz	
Transmitter duty cycle					1	%	(2)

NOTE 1 The standard is optimised for the 868-870 MHz band, but with local radio approval, it may allow operation in other frequency bands, e.g. 433 MHz.

NOTE 2 Duty cycle as defined by EN 300220-1.

See the graphic for frequency and power recommendations in annex A.

6.2 Mode R2 : Transmitter

The parameters for the transmitters are there below.

Table 19 — Mode R2, transmitter

Characteristic	Type/ Class	Sym	Min	Typ	Max	Unit	Note
Centre frequency, (other)				868,330		MHz	
Centre frequency (meter)				868,030 +n*0,06		MHz	
Frequency tolerance (meter / other)			-17	0	+17	kHz	~20ppm
FSK Deviation			+/-8	+/-6	+/-7,2	kHz	
Chip rate Wakeup and Communications				4.8		kcps	
Chip rate tolerance (Wakeup and Communications)			-1,5	0	+1,5	%	
Digital bit jitter					+/-15	us	(1)
Data rate (Manchester encoding)				f_{chip} *1/2		bps	(2)
Preamble length including bit / byte-sync			96			chips	
Postamble (trailer) length			2		8	chips	(3)
Response delay (other)		t_{RO}	3		50	ms	(4)
Response delay (Meter)		t_{RM}	10		10000	ms	(4)

NOTE 1 The bit jitter is measured at the output of the micro-controller or encoder circuit.

NOTE 2 Each bit is coded as 2 chips (Manchester coding).

NOTE 3 The postamble (trailer) consists of n = 1 to 4 "ones" i.e. the chip sequence is n*(01).

NOTE 4 Response delay : after transmitting a telegram, the receiver must be ready for the reception of a response in a time shorter than the minimum response delay, and must be receiving for the duration of the maximum answer delay, which is given in case of CI= 81_h by the application layer for R2 mode.

6.3 Mode R2 : Receiver

Table 20 — Mode R2, receiver

Characteristic	Class	Symb	Min	Typ	Max	Unit	Note
Sensitivity (BER 1 in 10^2) or block acceptance rate > 80 %	H_R	P_o	-105	-110		dBm	
Blocking performance	L_R		3			Class	(1)
Blocking performance	M_R		2			Class	(1) (3)
Blocking performance	H_R		2			Class	(1) (2) (3)
Acceptable chip rate range		f_{chip}	4,7	4,8	4,9	kcps	~ 2 %
Acceptable chip rate variation during header and telegram		Df_{chip}	-0.2	0	+0,2	%	

NOTE 1 Receiver class according to EN 300220-1, section 9.3.

NOTE 2 Additional requirement for the H_R receiver class: Blocking adjacent band and also adjacent channel. Rejection, 40 dB minimum, according to EN 300220-1, section 9.1 and 9.2 respectively.

NOTE 3 Additional requirement for M_R - H_R receiver class : Immunity test against radio frequency electromagnetic fields according to EN 301489-1, section 9.2 and EN 301489-3.

6.4 Mode R2 : Data Encoding

6.4.1 Mode R2 : Manchester encoding

Manchester encoding is defined for this mode to allow simple coding/decoding and a narrow base-band. Each bit is encoded either as "10" chip sequence representing a "zero" or as "01" representing a "one".

6.4.1.1 Mode R2 : Order of transmission of the encoded data

Each data byte is transmitted always with the most significant bit (MSb = Most significant bit) first.

The byte sequence of the CRC is with the high byte first, the byte sequence of the manufacturer field is with the low byte first. The byte sequence of other multi-byte field is not defined in this standard, however it is recommended that the low byte be first.

The lower frequency corresponds to a chip value of "0".

6.4.1.2 Mode R2 : Preamble chip sequences

The total preamble (header + synchronisation) chip sequence for this mode is n*(01) 0001110110 10010110 with n ≥ 39.

NOTE 1 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 telegram and an accidental “sync” sequences within an ongoing transmission.

NOTE 2 The data encoding is identical to mode S.

6.5 Mode R2 : Data link layer

The link layer of IEC 60870-5-2 with the format class FT3 is used, all chips of each telegram must form an uninterrupted chip sequence.

6.5.1 Mode R2 : Frame format

The general format of the frame is the following.

6.5.1.1 Mode R2 : First block

Table 21 — Mode R2, first block

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

6.5.1.2 Mode R2 : Optional second block

Tableau 22 — Mode R2, optional second block

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

6.5.1.3 Mode R2 : Other optional block

Table 23 — Mode R2, other optional block

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

6.5.2 Mode R2 : Field definitions

The fields are defined in IEC 60870-5-2 as follow.

6.5.2.1 Mode R2 : L : Length field

The first byte of the first block is the length field (L = 0 to 255), which signals the total number of user bytes (excluding the length field and the CRC’s). If ((L-9) MOD 16) is not zero, the last block contains ((L-9) MOD 16) data bytes + 2 CRC bytes. All the other blocks contain always 16 data bytes + 2 CRC bytes.

6.5.2.2 Mode R2 : C : Control Field

The second byte is the C-field, which signals the telegram type. According to IEC 60870-5-2 the following C-field codes are used :

- the C-field value $C=46_h$ is used to signal if the meters are in the installation mode ;
- for the sub-mode R2 all C-field values of IEC 60870-5-2 may be used, for example $C=4B_h$ (request/respond), $C=08_h$ (respond), $C=44_h$ (send/no reply) ;
- for the transmit only mode, the C-field value $C=44_h$ (send-no-Reply) is used.

6.5.2.3 Mode R2 : M : Manufacturer ID

The bytes 3 and 4 of the first block contain 2 bytes for a unique user/manufacturer ID of the meter, which is formed from an ASCII-three letter code (A..Z) according to EN 1434-3 (see annex B for administration). These two bytes are transmitted low byte first.

If the Most significant bit of this two bytes unique user/manufacturer ID is equal to zero, the address A is a unique (hard coded) manufacturer meter address of up to 6 bytes. Each manufacturer is responsible for the world-wide uniqueness of these 6 bytes. He may use any type of coding or numbering, including type/version/date as long as this uniqueness requirement is fulfilled.

If the Most significant bit of this two bytes code unique user/manufacturer ID is different from zero, the 6 byte address is unique at least within the maximum transmission range of the system (soft address), which is usually assigned to the device at installation time. As long as these unique address requirements are fulfilled, the remaining bytes can be used for user specific purposes.

6.5.2.4 Mode R2 : A : Address

This address A must be unique (at least within the maximum transmission range). Each user/manufacturer must guarantee that this ID is unique.

6.5.2.5 Mode R2 : CI Control Information Field (1 byte)

Located at the beginning of the second block, the CI field indicates the type of protocol and thus the nature of the information which are following. The CI value is :

Table 24 — CI Control information field

Ci value	Designation	Remarks
51_h	Data send by the Readout device to the meter, without fixed header to be defined	For compatibility with the future M-Bus application layer standard
71_h	Reserved for Alarm Report	For compatibility with the future M-Bus application layer standard
72_h	M-Bus Application Layer with full header	For compatibility with the future M-Bus application layer standard
78_h	M-Bus Application Layer without header to be defined	For compatibility with the future M-Bus application layer standard
$7A_h$	M-Bus Application Layer with short Header	For compatibility with the future M-Bus application layer standard
81_h	Relaying Application Layer	See chapter 7
82_h	For future use	For compatibility with future CENELEC TC 205 standard
$A0_h$-$B7_h$	Manufacturer specific Application Layer	

6.5.3 Mode R2 : CRCx : Cyclic Redundancy Check

The most significant bit is sent first. The CRC is computed over the information from the previous block , and is according to FT3 of IEC 60870-5-1 with the following formula :

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.

7 Optional relaying and multiple addressing functionality with CI=81_h

The relaying allows a message to be transferred to a final destination through a number of hopes. The usual way is from a handheld which sends a message to a pre-assigned radio unit. This pre-assigned radio unit forwards the message to the next pre-assigned unit and so far up to the final meter. The final meter will execute the command and eventually forward a message back to the handheld through the same route.

A single readout request can initiate a sequential response from a group of 1 to 7 meters. If this group of meters can not be communicated directly, then the handheld can assign 1 to 3 other meters to act as repeaters for this group of meters.

The primary station is the handheld terminal and the final station is the radio module connected to the meter.

The frame structure below represents the data link layer and the network layer extension (fields CN to RM) for the CI field 81_h.

7.1 Frame structure after the first block

Table 25 — Frame structure after the first block

CI 81 h	CN	DA_m	[t_{RM}]	[t_{FBA}]	[AP]	[RM]	DATA	CRCx
1	1	m*8	1	1	r	r*8	d	2

7.1.1 Frame field

CRCx : Cyclic Redundancy Check for the packet x ;

CI : Control information ;

CN : Control Node (see description below) ;

DA_m : Destination Address m. The first 8 bytes represent the first end station to address in multiple station addressing. The meter should check if its own address is present in this field. In function of his position in this field, the meter should wait a time delay t_{RI} before sending the response. For the response, the only destination address is the address of the handheld unit ;

t_{RM} : response delay of the last station, which is the meter that will be read, to reply to the request. This field is an optional field and it is present only if the number of repeaters is >0 (b6, b5 of CN) and/or if the number of destination address is > 1. This field represents the time for the end station to process the request, which is the time to recover the meter information and the time to prepare the response. This value is also used to compute the time-out for the return to the standby mode. The unit is 480 chips (equal to 100 ms for 4800 cps). Note : for the other stations, the response delay is t_{RO} ;

t_{FBA} : total response frame duration, including the preamble, from the meter to the next station. This field is an optional field and he is present only if the number of repeaters is > 0 (b6, b5 of CN) and/or if the number of destination address is > 1. The value is also used to compute the time out for the return to the standby mode. The unit is 48 chips (equal to 10 ms for 4800 cps).

AP : Additional preamble duration used by each repeater. This field is an optional field and is present only if the number of repeaters is > 0 (b6, b5 of CN). The value is also used to compute the time out for the return to the standby mode. The total preamble duration is equal to the minimum preamble length increased by the value of this field. The unit is 48 chips (equal to 10 ms for 4800 cps) ;

RM : Relay Management. This field is an optional field which is present only if the number of repeaters is > 0 (b6, b5 of CN). The first 8 bytes represent the next repeater address ;

DATA data of the application. The first byte of this data field is a CI control information as defined in § 4.5.2.5 or § 6.5.2.5, 81_h excluded.

7.1.2 Control Node (CN)

Table 26 — Control Node CN

b7	b6	b5	b4	b3	b2	b1	b0
Reserved	Number of repeaters : r		Relaying counter : c		Number of destination address : m		
	0 for no repeater		At the first hope = number of repeaters		0 for broadcasting in transmit only mode for individual addressing		
	1 to 3 for one to three repeaters		Decreased by 1 at each hope		2 to 7 for multiple addressing		

The Control Node field indicates :

r : the number of repeaters between the readout system and the meter. This number is limited to 3 in this protocol ;

c : the relaying counters, which is equal to r at the first hop, and then is decreased by 1 at each hop when the message is transmitted sequentially from the readout system to each relay and will be zero inside the message of the last hope transmission ;

m : the number of destination address is the total of meters that could receive the messages from the last repeater, in the option of multiple addressing.

See the annex E for the calculation of the fields RMx, APx.

7.2 Management of the fields concerned by the relaying

In the following example, one hand held unit D4 sends a message through the repeaters D3, D2 and D1 to the 7 meters D01, D02 to D07 in multi-addressing mode.

< ----- **D01**

D4 <==> **D3** <==> **D2** <==> **D1** ---> < ----- **D02**

< ----- **D07**

Figure 2 — Management of the fields concerned by the relaying

The first Table shows the first frame transmitted by hand held unit D4 and received by repeater D3.

Table 27 — Management of the fields concerned by the relaying (first)

SA	CN	DA1	DA2	DA3	DA4	DA5	DA6	DA7	AP1	AP2	AP3	RM1	RM2	RM3
D4	01111111	D3	D02	D03	D04	D05	D06	D07	APD3	APD2	APD1	D2	D1	D01

and the second table shows the frame transmitted by the repeater D3 to the repeater D2.

Table 28 — Management of the fields concerned by the relaying (second)

SA	CN	DA1	DA2	DA3	DA4	DA5	DA6	DA7	AP1	AP2	AP3	RM1	RM2	RM3
D3	01110111	D2	D02	D03	D04	D05	D06	D07	APD2	APD1	0	D1	D01	D4

8 All mode : Connection to Higher OSI layers.

The mechanism of communication from the data link layer to a higher OSI layer uses the values of the CI field, defined in the tables § 4.5.2.5, § 5.5.2.5 and § 6.5.2.5 and which signals the structure of the higher layers, e.g. M-Bus. The corresponding message have more than one block, and the first byte of the second block is this CI field, the rest of the message is application dependant.

Annex A
(informative)

Frequency allocation and band usage

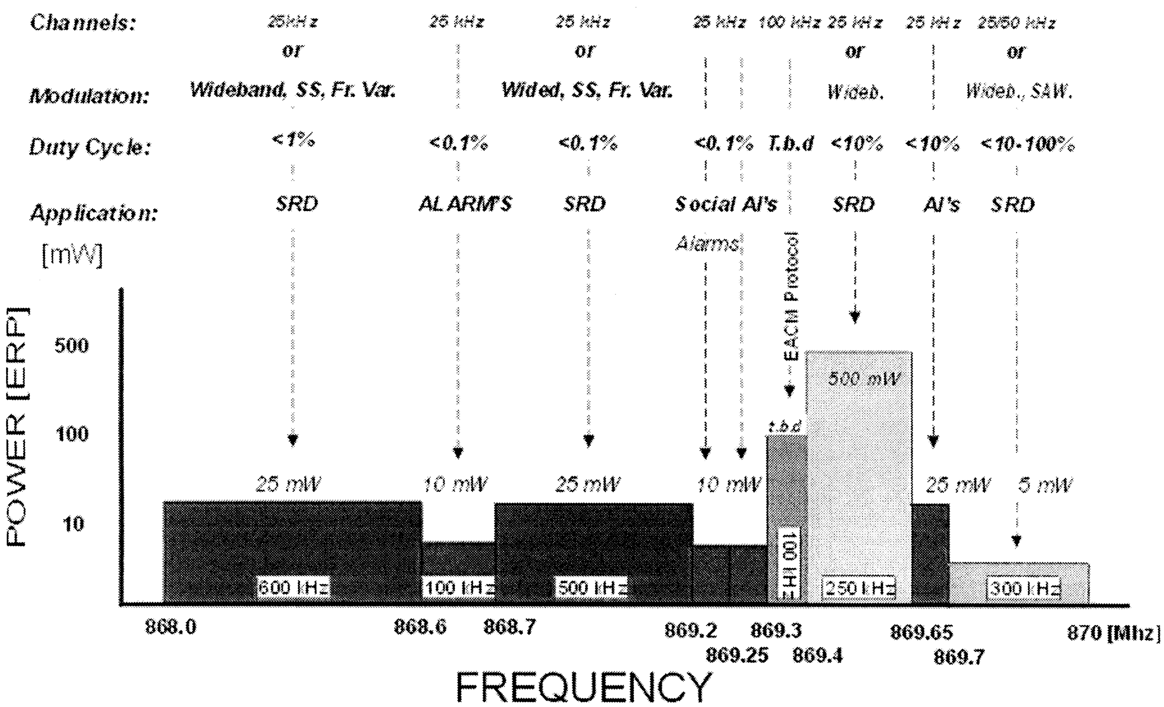

Figure A.1 — Frequency allocation and band usage

Annex B
(informative)

Flag

For information, assignment of the “unique user/manufacturer ID”, three letter codes.

The unique user : manufacturer code is presently administrated by :

The Flag Association Ltd
c/o Siemens Measurement Ltd
Manchester Road
Oldham OL97JS
United Kingdom.
http://www.dlms.com/flag/index.htm

Annex C
(informative)

Mode S1 - example

Example of the telegram from the Mode S1 meter.

The application layer telegram 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 manufacturer specific (hexadecimal) production number "070112345678h" transmits a (decimal) volume of 876543 litres.

For the example this is coded according to EN 1434-3 as : DIF=$0B_h$ (=6 digit BCD instantaneous value) and VIF=13_h (=volume in litters).

The "CEN" is coded according to EN 1434-3 as "C"=ASCI (C) (=43_h)-40_h=3_h, "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.

Thus the telegram consists of two CRC-blocks :

1) CRC block: length=10 byte (by definition of this standard)+2 byte CRC :

of_h	L-field according to IEC 60870-5 ;
44_h	C-field according to IEC 60870-5 ;
$0CAE_h$	Manufacturer code ;
070112345678_h	Manufacturer number (e.g. Medium, Version, Ident-Nr.) :

2) The second block has the CI-field plus 5 user bytes + 2 bytes CRC :

78_h	Meter ID in header, starts directly with VIF/DIF ;
$0B_h$	DIF=3 Byte BCD instantaneous value ;
13_h	VIF = Volume in litres ;
876543_h	Number of litres (in BCD).

Since multi-byte data are (according to EN 1434-3) transmitted LSB first, the hex byte sequence without CRC's is :

of 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 IEC 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 :

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

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, the bit-sync pattern and the trailer this leads to the following total continuous chip string :

010101010101010101010101010101010101010101010101010101010101010101010101010101010101

010101010101010101010101010101010101010101010101010101010101010101010101010101010101

010101010101010101010101010101010101010101010101010101010101010101010101010101010101

010101010101010101010101010101010101010101010101010101010101010101010101010101010101

010101010101010101010101010101010101010101010101010101010101010101010101010101010101

010101010101010101010101010101010101010101010101010101010101010101010101010101010101

010101010101010101010101010101010101010101010101010101000111011010010110

10101010010101011001101010011010011001100101011010101010010110101001010101101010

10011001100101101010010110011010101010011010011010101010101010011010101010010101

10011010100110101001101010010101100101010110101010101010011001011010100110100101

10011010101001011001011010011001011010101001010110101001010101101001011001011001 01

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

Annex D
(informative)

Mode T1 - example

Example of the telegram from a meter in mode T1.

The application layer telegram 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 manufacturer specific (hexadecimal) production number "070112345678h" transmits a (decimal) volume of 876543 litters.

For the example this is coded according to EN 1434-3 as : DIF=0Bh (=6 digit BCD instantaneous value) and VIF=13_h (=volume in litters).

The "CEN" is coded according to EN 1434-3 as "C"=ASCI (C) (=43h)-40h=3h, "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.

Thus the telegram consists of two CRC-blocks :

1) CRC block: length=10 byte (by definition of this standard)+2 byte CRC :

of_h	L-field according to IEC 60870-5 ;
44_h	C-field according to IEC 60870-5 ;
$0CAE_h$	Manufacturer code ;
070112345678_h	Manufacturer number (e.g. Medium, Version, Ident-Nr.)

The second block has the CI-field plus 5 user bytes + 2 bytes CRC :

78_h	Meter ID in header, start directly with VIF/DIF ;
$0B_h$	DIF=3 Byte BCD instantaneous value ;
13_h	VIF = Volume in litres ;
876543_h	Number of litres (in BCD).

Since multi-byte data are (according to EN 1434-3) transmitted LSB first, the hex byte sequence without CRC´-s is :

of 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 IEC 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 :

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

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_synchronisation 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 a mode T1 the nominal chip rate for communication is 100 kcps, with a the transmit duration of 2.9 ms.

Annex E
(normative)

Optional relaying and multiple addressing (CI = 81_h)

E.1 Use of fields' t_{RM}, t_{FBA}, AP for time out calculation : Example with 2 repeaters and 2 final stations

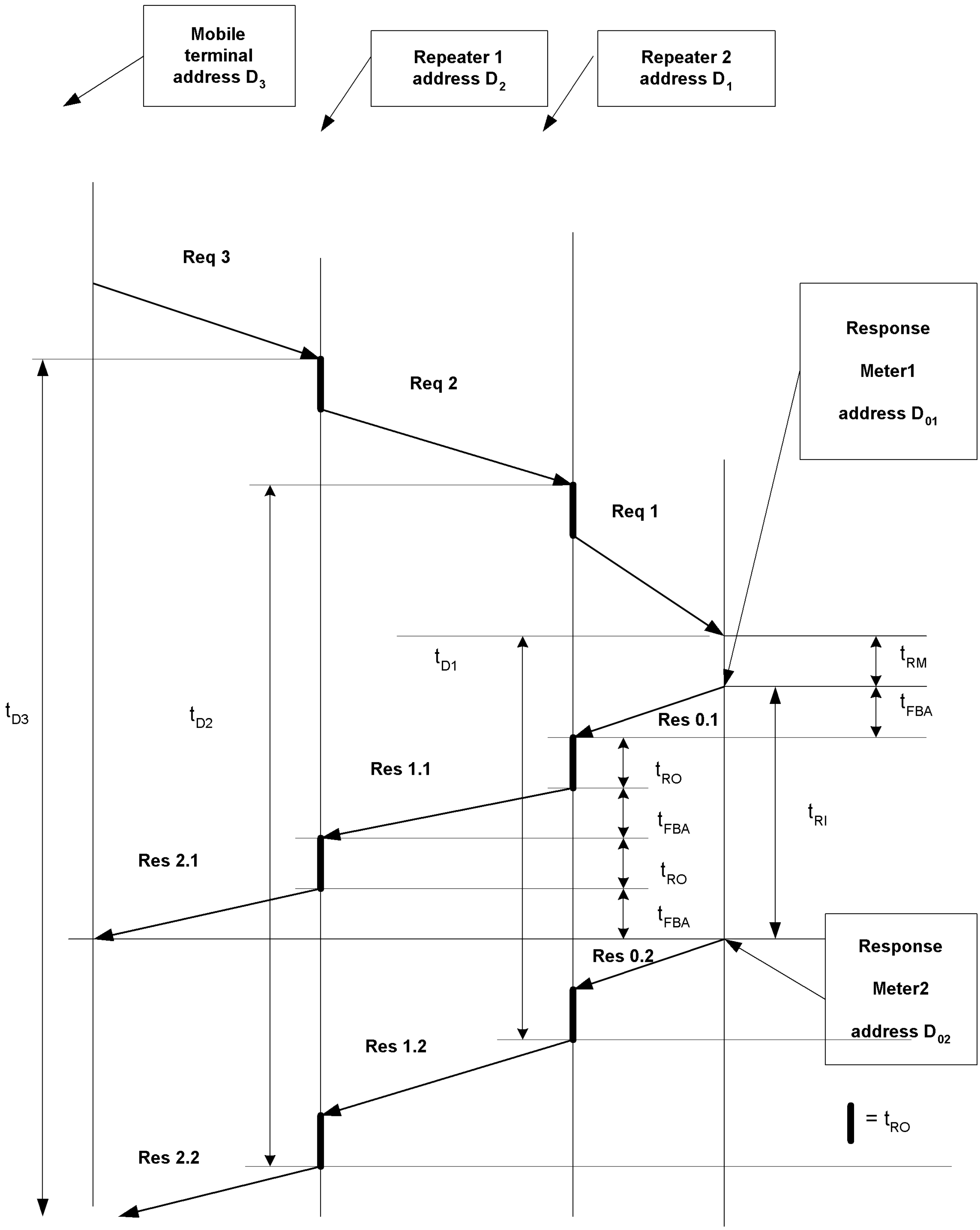

Figure E.1 — Use of fields' t_{RM}, t_{FBA}, AP for time out calculation

E.2 List of symbols and definitions

D_n the address of the primary station (initiator mobile terminal) ;

D_{0m} $m \subset [1..7]$, the address of the m final station (meter) ;

D_i $i \subset [1..3]$, the address of the repeater ;

t_{RM} the response delay of the meter ;

t_{RO} the response delay of the other stations ;

t_{RI} the time interval between two end station response ;

t_{Di} the maximum time delay necessary to receive the response for station D_i ;

r the number of repeaters ;

m the number of final station ($m \subset [1..7]$) in multi stations communications ;

APD_i the additional preamble duration used by the repeater D_i ;

RL request length (total number of chips) ;

CR the chip-rate ;

$t_{i,i\text{-}1}$ the communication time between D_i and $D_{i\text{-}1}$.

We get :

$t_{i,i-1} = APD_i + (RL/CR) + t_{RO}$;

$t_{i,0} = \Sigma\, [k=1 \text{ to } i]\, (APD_k) + i\, ((RL/CR) + t_{RO})$;

$t_{RI} = (r+1)t_{FBA} + r\, t_{RO}$;

$t_{Di} = t_{RM} + t_{i-1,0} + i\, (t_{FBA} + t_{RO}) + (m-1)\, t_{RI}$;

$t_{Di} = t_{RM} + t_{i-1,0} + (i + (r+1)(m-1))\, t_{FBA} + (i + r(m-1))\, t_{RO}$.

For the example : $r = 2$, $m = 2$ t

the interval between response from the two final stations is :

$t_{RI} = 3t_{FBA} + 2t_{RO}$

The maximum time delay necessary to receive the response is for :

Station D_1 : $t_{D1} = t_{RM} + 0 + (t_{FBA} + t_{RO}) + t_{RI}$

$t_{D1} = t_{RM} + 4\ t_{FBA} + 3\ t_{RO}$

Station D_2 : $t_{D2} = t_{RM} + APD_1 + RL/CR + t_{RO} + 2(t_{FBA} + t_{RO}) + t_{RI}$

$t_{D2} = t_{RM} + APD_1 + RL/CR + 5\ t_{FBA} + 4\ t_{RO})$

Station D_3 $t_{D3} = t_{RM} + APD_1 + APD_2 + 2\ RL/CR + 2\ t_{RO} + 3\ (t_{FBA} + t_{RO}) + t_{RI}$

$t_{D3} = t_{RM} + APD_1 + APD_2 + 2\ RL/CR + 6\ t_{FBA} + 5\ t_{RO}$

E.3 Frames

Table E.1 — Frames

Size	**1**	**1**	**8**	**2**	**1**	**1**	**n*8**	**1**	**1**	**r**	**r*8**		
Field	L	C	SA	CRC1	CI	CN	DA_m	t_{RM}	t_{FBA}	AP	RM	Data	CRCx
Req3	L	C	D_3	CRC1	CI	01010010	D_2, D_{02}	t_{RM}	t_{FBA}	APD_2, APD_1,	D_1, D_{01}	Req	CRCx
Req2	L	C	D_2	CRC1	CI	01001010	D_1, D_{02}	t_{RM}	t_{FBA}	APD1, 0,	D_{01}, D_3	Req	CRCx
Req1	L	C	D_1	CRC1	CI	01000010	D_{01}, D_{02}	t_{RM}	t_{FBA}	0, 0,	D_3, D_2	Req	CRCx
Res0.1	L	C	D_{01}	CRC1	CI	01010001	D_1	t_{RM}	t_{FBA}	0, 0,	D_2, D_3	Res	CRCx
Res1.1	L	C	D_1	CRC1	CI	01001001	D_2	t_{RM}	t_{FBA}	0, 0	D_3, D_{01}	Res	CRCx
Res2.1	L	C	D_2	CRC1	CI	01000001	D_3	t_{RM}	t_{FBA}	0, 0	D_{01}, D_1	Res	CRCx
Res0.2	L	C	D_{02}	CRC1	CI	01010001	D_1	t_{RM}	t_{FBA}	0, 0	D_2, D_3	Res	CRCx
Res1.2	L	C	D_1	CRC1	CI	01001001	D_2	t_{RM}	t_{FBA}	0, 0	D_3, D_{02}	Res	CRCx
Res2.2	L	C	D_2	CRC1	CI	01000001	D_3	t_{RM}	t_{FBA}	0, 0	D_{02}, D_1	Res	CRCx

NOTE Station D3 (Mobile terminal) knows APD_3 for Req3.

Station D2 uses APD_2 for Req2.

Station D1 uses APD_1 for Req1.

Source address SA.

Destination address DA.

AP = 0 for all responses ; Don't care about the value of the fields t_{RM}, t_{FBA} and AP for the response.

Req 1 : At this time, the stations (D_{01}) (D_{02}) (D_{03}) will receive this frame with c = 0 in the field CN, meaning that it has reached its final destination. The station (D_{01}) (D_{02}) (D_{03}) initialises A, DA, RM and send :

Res0.1 as soon as possible.

Res0.2 after a delay equal to t_{RI}.

E.4 Relaying algorithm

It is the responsibility of the application layer of the primary station initiator to know which equipment has to be used as a repeater. Let's note D_n the address of the primary station initiator, D_{01} the address of the final secondary station and D_i, $i \subset [1..3]$, the address of the repeaters used to forward the frame.

$$\begin{array}{ccccccc} & \text{---->} & & \text{---->} & & \text{---->} & \\ \mathbf{D}_{\boldsymbol{n}} & & \mathbf{D}_{\boldsymbol{n}\text{-}\mathbf{1}} & & \mathbf{D}_{\mathbf{1}} & & \mathbf{D}_{\mathbf{01}} \\ & \text{<----} & & \text{<----} & & \text{<----} & \end{array}$$

Figure E.2 — Relaying algorithm

The routing algorithm is given below, where it is assumed that only one frame has to be exchanged to complete the transfer.

Let assumes that r represents the numbers of repeaters, c the relaying counter and DA_1 the first destination address in the field DA_m.

A. Primary station performs the following initialisation :

1. $R = r$, $c = r$, $n = r+1$;
2. $A = D_n$, $DA_1 = D_{n\text{-}1}$;
3. $[AP_1, ..., AP_{n\text{-}1}] = [APD_{n\text{-}1}, ..., APD_1]$;
4. $RM = [D_{n\text{-}2}, ..., D_1, D_{01}]$;
5. compute the time out to return to standby mode.

B. Primary station sends the frame.

C. For each D_i, $i \subset [1\ n\text{-}1]$, receiving a frame with c ≠ 0, do the following :

1. decrement c ;
2. perform a left address rotation on the set {A, DA1, RM} ;
3. prepare the frame with the AP_1 Preamble ;
4. AP_1= 0. Perform a left preamble rotation on the set $\{APD_i\}$;
5. compute the time out to return to standby mode ;
6. send the frame.

D. When a received frame has c = 0, then DA_1 = secondary station, i.e., the frame has reached its final destination. Secondary station then reinitialises A, DA_1, RM and c :

1. $c = r$;
2. exchange $(A, DA_1)3$;
3. for (i = 0 ; $i \leq n/2$; i++) Exchange (RM[i], RM[n-i-1]).

Bibliography

[1] Directive CE 99/5/EC, *Radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity*.

[2] *Radian protocol for 868 MHz will generally be derived from the present Radian Protocol which may be found on the Radian user association Web Site, http://www.radianprotocol.com/.*

[3] ANSI C63.5:1998, *American National Standard for Calibration of Antennas Used for Radiated Emission Measurements in Electromagnetic Interference (EMI) ControlCalibration of Antennas (9 kHz to 40 GHz)*.