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ICS 33.200; 35.100.10; 35.100.20

Kommunikationssysteme für Zähler und deren Fernablesung – Teil 2: Physical und Link Layer; Englische Fassung EN 13757-2:2004

Communication systems for and remote reading of meters –
Part 2: Physical and link layer;
English version EN 13757-2:2004

Systèmes de communication et de télérelevé de compteurs –
Partie 2: Couches physique et couche de liaison;
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Diese Norm gilt ab 2005-02-01.

Nationales Vorwort

Diese Europäische Norm wurde vom Technischen Komitee CEN/TC 294 „Kommunikationssysteme für Zähler und deren Fernablesung“ (Sekretariat: AFNOR) erarbeitet und der englische Originaltext unverändert übernommen. Der Arbeitsausschuss 3.66 „Kommunikationssysteme für Zähler und deren Fernablesung“ im Normenausschuss Heiz- und Raumlufttechnik (NHRS) war für das DIN Deutsches Institut für Normung e. V. an der Erstellung dieser Norm beteiligt.

Das Präsidium des DIN hat mit seinem Beschluss 1/2004 festgelegt, das von dem in den Regeln der europäische Normungsarbeit von CEN/CENELEC verankerten Grundsatz, wonach Europäische Normen in den drei offiziellen Sprachen Deutsch, Englisch, Französischer veröffentlicht werden, in begründeten Ausnahmefällen abgewichen und auf die Deutsche Fassung verzichtet werden kann. die Genehmigung dafür hat die DIN-Geschäftsleitung entsprechend ihren in Anlage 1 zu dem DIN-Rundschreiben A 5/2004 festgelegten Kriterien für die vorliegende Norm auf Antrag des NHRS als Ergebnis einer Einzelfallentscheidung erteilt, zumal bereits dieser Norm zugrunde liegende Papiere überwiegend in englischer Sprache auch von den deutschen Markteilnehmern angewendet werden.

Da sich die Benutzer der vorliegenden Norm der englischen Sprache als Fachsprache bedienen, wird die englische Fassung der DIN EN 13757-2 veröffentlicht.

Eine deutsche Einführung für den Anwendungsbereich und eine allgemeine Beschreibung befinden sich im Teil 1 der Normenreihe DIN EN 13757.

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 13757-2

November 2004

ICS 33.200; 35.100.10; 35.100.20

English version

Communication systems for and remote reading of meters Part 2: Physical and link layer

Systèmes de communication et de télérelevé de compteurs — Partie 2: Couches physique et couche de liaison

Kommunikationssysteme für Zähler und deren Fernablesung — Teil 2: Physical und Link Layer

This European Standard was approved by CEN on 23 September 2004.

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. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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Contents

Foreword

This document (EN 13757-2:2004) has been prepared by Technical Committee CEN/TC 294 “Communication systems for meters and remote readng of meters”, the secretariat of which is held by AFNOR.

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 May 2005, and conflicting national standards shall be withdrawn at the latest by May 2005.

This standard consists of the following parts:

EN 13757-1, *Communication system for meters and remote reading of meters — Part 1: Data exchange.*

EN 13757-2, *Communication systems for and remote reading of meters — Part 2: Physical and link layer.*

EN 13757-3, *Communication systems for and remote reading of meters — Part 3: Dedicated application layer.*

prEN 13757-4, *Communication systems for meters and remote reading of meters — Part 4: Wireless meter readout.*

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

Introduction

The physical and link layer parameters for baseband communication over twisted pairs has first been described in EN 1434-3:1997 ("M-Bus") for heat meters. This standard is a compatible and interworking update of a part of EN 1434-3:1997 and includes also other measured media (water, gas, heat cost allocators), the master side of the communication and newer technical developments. It should be noted that the EN 1434-3:1997 covers also other communication techniques.

It can be used with various application layers especially the application layer of EN 13757-3.

1 Scope

This document covers the physical and link layer parameters of baseband communication over twisted pair (M-Bus) for meter communication systems. It is especially applicable to heat meters, heat cost allocators, water meters and gas meters.

NOTE It is usable also for other meters (like electricity meters) and for sensors and actuators.

For generic descriptions concerning communication systems for meters and remote reading of meters see EN 13757-1.

2 Normative references

The following referenced documents are indispensable for the application 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 60870-5-2, *Telecontrol equipment and systems — Part 5: Transmission protocols — Section 2: Link transmission procedures (IEC 60870-5-2:1992).*

EN 61000-4-4, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 4: Electrical fast transient/burst immunity test — Basic EMV publication (IEC 61000-4-4:1995).*

EN 61000-4-5, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 5: Surge immunity test (IEC 61000-4-5:1995).*

3 Terms and definitions

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

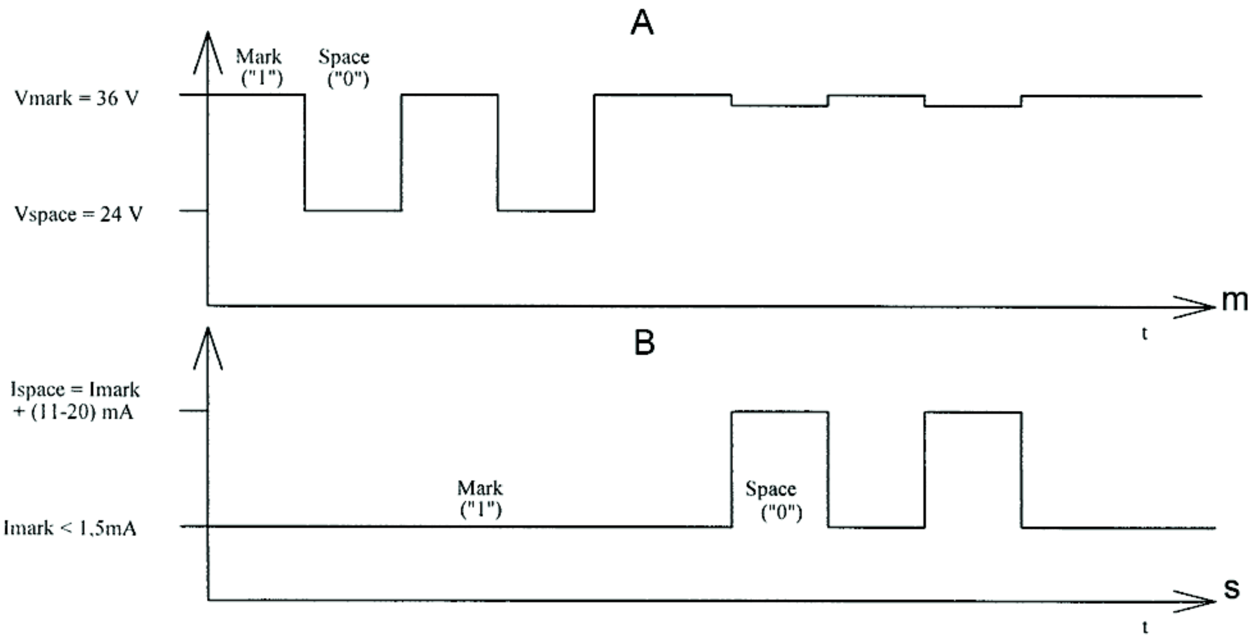
3.1
unit load
one unit load (1 U_L) is the maximum mark state current of 1,5 mA

3.2
other definitions
for further definitions see 4.6 and annex C of EN 13757-1:2002

4 Physical layer specifications

4.1 General

Figure 1 shows the principal electrical concept of the physical layer: Information from the master to the slaves is transmitted via voltage level changes. A (high) quiescent voltage level Umark (idle state, typically 36 V) and an active voltage level (space state) which is typically 12 V below Umark (but at least 12 V) is used for the data transmission. The high voltage step improves the noise immunity in the master to slave direction. The required minimum voltage supports continuous remote powering of all slaves of a segment. Signalling via a voltage change rather than by absolute voltage levels supports even large voltage drops due to wiring resistance of the cable installation. All slaves are constant current sinks. Their idle (mark state) current of typically 1,0 mA to 1,5 mA can be used for powering the transceiver IC in the slave and optionally also the slave (meter). The active (space state) current transmit of a slave is signalled by an increase of this constant current by (11…20) mA. Signalling via constant current improves the immunity against induced voltages and is independent on wiring resistance. On the input of each slave transceiver a rectifier bridge makes each slave independent of the wiring polarity and reduces installation errors. Protective resistors in front of each slave transceiver simplify the implementation of overvoltage protection and safeguards the bus against a semiconductor short circuit in a slave by limiting the current of such a defective slave to 100 mA. Annex A shows the principal function of a slave transceiver. Integrated slave transceivers which include a regulated buffered voltage output for slave (meter) powering, support of battery supply with supply switchover and power down signallong are commercially available.



Key

A Bus Voltage at Repeater
B Current composition of a Slave
t Time
m Master transmits to Slave
s Slave transmits to Master

Figure 1 — Representation of bits on the M-Bus

All specification requirements shall be held over the full range of temperature and operating voltage for the responsible system component.

4.2 Electrical requirements slave

4.2.1 Master to slave bus voltages

Maximum permanent voltage : – 50 V … 0 V … + 50 V (no damage).

Voltage range for meeting all specifications: ± (12 V … 42 V).

The Bus voltage at the slave terminals in mark-(quiescent) state of master slave communication (= U_{Mark}) shall be ± (21 V … 42 V).

The mark voltage shall be stored by a voltage maximum detector with an asymmetric time constant. The discharge time constant shall be greater than 30 × (charge constant) but less than 1 s.

The stored voltage maximum U_{Mark} may drop in 50 ms by not more than 0,2 V for all voltages between 12 V and U_{Mark}.

Bus voltage Mark/Space state for master slave communication.

Space: $U_{\mathrm{Bus}} < U_{\mathrm{Mark}} - 8{,}2$ V

Mark: $U_{\mathrm{Bus}} \geq U_{\mathrm{Mark}} - 5{,}7$ V

Maximum space state time 50 ms.

Maximum space state duty cycle: 0,92.

4.2.2 Slave bus current and multiple unit loads

4.2.2.1 General

A slave device may require a maximum mark current of an integer multiple N (in the range 1 … 4) unit loads. Each terminal device shall be marked with the unit load number N (If > 1) and the device description shall contain a note on the multiple unit loads for this device.

4.2.2.2 Mark state bus current of a slave device

The mark state current I_{Mark} shall be $\leq N$ unit loads.

4.2.2.3 Variation of the mark state current over bus voltage

For bus voltages in the range of ± (12 V … 42 V) a voltage variation of 1 V … 15 V shall not change the bus current by more than $N \times 3$ µA/V.

4.2.2.4 Short term variation of the mark state current

At constant bus voltage the bus current shall not change by more than ± 1 % within 10 s.

4.2.2.5 Total variation over allowed temperature and voltage range of slave device

The total variation of the mark state current of a slave device shall not vary by more than ± 10 % over the full voltage and temperature range of the slave device.

4.2.2.6 Max. bus current for any single semiconductor or capacitor defect

1 min after any single semiconductor or capacitor defect the max. current of any slave device shall be less than 100 mA for any bus voltage ≤ 42 V.

4.2.2.7 Slow start

For any bus voltage in the range of (0 … ± 42) V the bus current shall be limited to $\leq N \times U_L$.

4.2.2.8 Fast change

After any bus voltage change the bus current shall be $\leq N \times U_L$ within 1 ms.

4.2.2.9 Space-Send current

The bus current for a slave space state send shall be higher by (11 … 20) mA than in the mark state for all allowed bus voltages:

$I_{\mathrm{Space}} = I_{\mathrm{Mark}}$ + (11 … 20) mA.

4.2.2.10 Input capacitance at the slave terminals: ≤ 0,5 nF

This capacitance shall be measured with a DC-bias of (15 to 30) V.

4.2.2.11 Startup delay

In case of a bus voltage drop below 12 V for longer than 0,1 s the recovery time after applying an allowed mark state voltage until reaching full communication capabilities shall be less than 3 s.

4.2.2.12 Galvanic Isolation

The isolation resistance between any bus terminal and all metal parts accessible without violating seals shall be > 1 MOhm. Excluded are terminals for the connection of other floating or isolated external components. The test voltage is 500 V. For mains operated terminal devices the appropriate safety rules apply.

4.2.2.13 Optional reversible mains protection

The slave interface can be equipped with an optional reversible mains protection. This guarantees that even for a prolonged period (test duration: 1 min) the slave interface can withstand mains voltages of 230 V + 10 % and 50 Hz or 60 Hz and that afterwards all specifications are met again. This mains protection function is recommended for all mains operated terminal devices. For possible implementations see annex B.

4.2.3 Dynamic requirements

Any link layer or application layer protocol of up to 38 400 Baud is acceptable if it guarantees that a mark state is reached for at least one bit time at least once in every 11 bit times and not later than after 50 ms. Note that this is true for any asynchronous protocol with 5 data bits to 8 data bits (with or without a parity bit) for any baud rate of at least 300 Baud, including a break signal of 50 ms. It is also true for many synchronous protocols with or without bit coding.

4.3 Electrical requirements master

4.3.1 Parameters

4.3.1.1 Max current (I_{Max})

A master for this physical layer is characterized by its maximum current I_{Max}. For all bus currents between zero and I_{Max} it shall meet all functional and parametric requirements. For example a maximally loaded segment with up to 250 slaves with 1 U_L each (375 mA) plus an allowance for one slave with a short circuit (+ 100 mA) plus the maximum space send current (+ 20 mA) an $I_{Max} \geq 0,5$ A is required.

4.3.1.2 Max allowable voltage drop (U_r)

The max. voltage drop U_r (> 0 V) is defined as the minimum space state voltage minus 12 V. U_r divided by the maximum segment resistance between the master and any terminal device (meter) gives the maximum usable bus current for a given combination of segment resistance and master.

4.3.1.3 Max baud rate (B_{Max})

Another characterisation of a master is the maximum baud rate B_{Max} up to which all specifications are met. The minimum baud rate is always 300 Baud.

4.3.1.4 Application description

Each master device shall include a description about the required cable and device installation for proper functioning.

4.3.2 Function types

4.3.2.1 Simple level converter

The master function can be realized as a logically transparent level converter between the M-bus physical layer and some other (standardized) physical layer (e.g. V24). It is then bit transparent for allowable baud rates of 300 … B_{Max}. No bit time recovery is possible. Hence a simple level converter can not be used as a repeater.

4.3.2.2 Intelligent level converter

An intelligent level converter can perform space bit time recovery for any asynchronous byte protocol at its maximum baud rate B_{Max}. Other baud rates B_{Max}/L (L = 2 … L_{Max}) are allowed, but bit time recovery can not be guaranteed for these other baud rates. Such a level converter can be used as a physical layer repeater for its maximum baud rate.

4.3.2.3 Bridge

The master function can be integrated with a link layer unit thus forming a (link layer) bridge. If this bridge can support the required physical and link layer management functions it can support also multiple baud rates.

4.3.2.4 Gateway

The master function can be integrated into the application layer of a gateway or it can be fully integrated into an application.

4.3.3 Requirements

4.3.3.1 Mark state (quiescent state) voltage

For currents between 0 … I_{Max}: U_{Mark} = (24 V + U_r) … 42 V.

4.3.3.2 Space state (signal state) voltage

$U_{Space} < U_{Mark}$ – 12 V, but ≥ 12 V + U_r.

4.3.3.3 Bus short circuit

Reversible automatic recovery shall guarantee full function not later than 3 s after the end of any current higher than I_{Max}.

1 ms after the beginning of a short circuit situation the bus current shall be limited to < 3 A.

4.3.3.4 Minimum voltage slope

The transition time between space state and mark state voltages from 10 % to 90 % of the steady state voltages shall be ≤ 1/2 of a nominal bit time. The asymmetry of these transition times shall be ≤ 1/8 of a nominal bit time.

Test conditions (C_{Load} selected from the E12 value series):

— baud rate 300 Baud: C_{Load} = 1,5 µF;

— baud rate 2 400 Baud: C_{Load} = 1,2 µF;

— baud rate 9 600 Baud: C_{Load} = 0,82 µF;

— baud rate 38 400 Baud: C_{Load} = 0,39 µF.

4.3.3.5 Effective source impedance

The voltage drop of the bus voltage for a short (< 50 ms) increase of the bus current by 20 mA shall be ≤ 1,2 V.

4.3.3.6 Hum, ripple and short term (< 10 s) stability of the bus voltages: < 200 mV peak to peak

4.3.3.7 Data detection current (Reception of slave current pulses)

Bus current ≤ Bus idle current + 6 mA: Mark state receive.

Bus current ≥ Bus idle current + 9 mA: Space state receive.

Measurement with current pulses of < 50 ms, duty cycle < 0,92.

4.3.3.8 Reaction at large data currents (collision)

Current increases of > 25 mA may be considered, current increases of > 50 mA shall be considered as a collision state. If for a duration of > (2 to 22) bit times the bus current signals such a collision state the master shall emit to the bus a break signal (bus voltage = U_{Space}) with a duration of ≥ 22 bit times but less than 50 ms. To the user side this state shall also be signalled with a break signal of equal duration. If the bus current is > I_{Max}, the master may switch off the bus voltage completely. Note that for switch off times > 100 ms the minimum recovery time of 3 s shall be taken into account.

4.3.3.9 Galvanic isolation

The isolation resistance between any bus terminal and all metal parts accessible without violating seals shall be > 1 MOhm. The test voltage is 500 V. For mains powered masters or masters with connection to ground based systems (e.g. connection to the V24 port of a mains powered PC) this includes isolation from these power respective signal lines. For mains powered masters the appropriate safety rules apply.

4.3.3.10 Ground symmetry

For mains powered masters or masters with connection to ground based systems (e.g. connection to the V24 port of a mains powered PC) the static and dynamic bus voltages shall be symmetric (40 % to 60 %) with respect to ground. This requirement is only valid for ground based systems.

4.4 Electrical requirements mini-master

4.4.1 Definition of a mini-master

A Mini-Master can be used in systems which can accept the following restrictions:

— maximum wiring length of its segment: ≤ 50 m;

— B_{Max}: 2 400 baud;

— no function required if any device fails with overcurrent;

— no automatic search for secondary addresses (collision mode) required.

A Mini-Master can be implemented as a simple level converter to some other standardized physical layer interface (e.g. V24) or it can be integrated into a data processing device. It usually can not be used as a repeater. It can be implemented as a stationary or as a portable device. It can be powered from mains or it can be battery powered.

4.4.2 Requirements

A Mini-Master has the following reduced requirements as compared to a full standard master:

4.4.2.1 Minimum transition slopes

For a load capacitance of 75 nF: Transition time between mark and space state voltages in both directions between 10 % and 90 % of the voltage step of the two static signal voltages: Maximum transition time t_{max} ≤ 50 µs.

4.4.2.2 Behavior at higher data currents (collision): No requirements

4.5 Repeaters

4.5.1 General requirements

A physical layer repeater shall meet at its slave side all requirements for a slave and at its master side all requirements of a master. Such a repeater is required in a net where one or several limits of the installation concerning maximum number of meters, maximum total cable length, maximum number of meters per segment or maximum distance are exceeded for the desired baud rate.

4.5.2 Additional requirements

4.5.2.1 Isolation

The bus terminals at the master side shall be isolated from the bus terminals at the slave side. The isolation resistance shall be ≥ 1 MOhm for the test voltage of 500 V. Any pertinent safety regulations for mains powered devices shall be considered.

4.5.2.2 Bit recovery

Incoming data bytes with acceptable bit time distortions for a reception according to the requirements of the link layer used shall be transmitted at the other side in such a way that all the transmit timing requirements of the link layer are met.

A repeater may therefore be restricted to certain baud rate(s) or may be restricted to certain byte formats or link layers.

4.6 Burst and surge requirements

4.6.1 General

A device according to this standard shall fulfil at least the following burst and surge requirements according to EN 61000-4-4 and EN 61000-4-5 for the M-bus connection. Note that device standards might impose further requirements or might impose higher requirements regarding burst and surge. Note also that the values have been updated from EN 1434-3 due to field experience.

4.6.2 Requirements for devices intended for domestic use

Burst test voltage: 1 kV (Severity class 2).

4.6.3 Requirements for devices intended for industrial use

Burst test voltage: 1 kV (Severity class 2).

Surge test voltage: 1 kV (Severity class 2).

5 Link Layer (master and slave)

5.1 General

The alphabetic percent designations (e.g. "W %") in the following clauses refer to the value specified in Table 1.

5.2 Baud rate

5.2.1 Required baud rate

300 Baud shall be supported.

5.2.2 Recommended additional baud rates:

2 400 Baud or 9 600 Baud are recommended.

5.2.3 Special baud rates:

By special arrangement between a net operator and a meter manufacturer also one or several of the following baud rates could be used: 600 Baud, 1 200 Baud, 4 800 Baud, 19 200 Baud or 38 400 Baud.

The total segment size and the number of connected slaves limits the technically safe maximum baud rate. (See cable installation section in annex E).

5.2.4 Baud rate after reset

The baud rate shall be kept after a reset of the device.

5.2.5 Baud rate set

The default baud rate of any device after fabrication is 300 Baud. A desired baud rate may be set by link layer management commands. (See the appropriate application layer commands). Broadcast baud rate set is not recommended. Immediately (< 2 min) after such a baud rate set command for a slave to a baud rate other than 300 Baud (transmitted at the old baud rate) a valid communication at the new baud rate shall be attempted. If (even after the appropriate number of retries) no acknowledge is received, the master shall set the slave baud rate back to the original baud rate via a baud rate set command at the attempted baud rate and then continue communication at the original baud rate. If the communication is acknowledged, the master knows that the slave and its segment can both operate at the new baud rate. A slave without an auto speed detect shall monitor after the reception of a baud rate set command to a baud rate other than 300 Baud for a valid communication at the new baud rate within 2 min to 10 min after the baud rate set command. If such a communication is not properly received, the slave shall switch back automatically to the previous baud rate to save it from being permanently lost in a baud rate which is not supported by its segment.

5.2.6 Auto speed mode

Devices may support communication with all supported baud rates without a prior baud rate set command (auto speed mode). In this case no baud rate switch command monitoring and auto fallback is required. All baud rate set commands shall still be acknowledged but can be ignored otherwise except for their FCB-administration (if required).

5.2.7 Transmit baud rate accuracy

The transmission baud rate averaged over any RSP_UD telegram may vary under all acceptable parameters (i.e. supply voltages, temperature, current operating state and function) by not more than $\pm M$ % of the nominal baud rate (see Table 1).

5.3 Bit position

5.3.1 Synchronous transmit bit distortion

For data transmission the individual bit transitions may have a non accumulating maximum deviation from their nominal time position (calculated from the actual baud rate) of up to N % of a bit time (Synchronous start-stop-distortion, see also Figure 2).

5.3.2 Gross transmit bit distortion and minimum signal element

For data transmission the individual bit transitions may have a non accumulating maximum deviation from their nominal time position (calculated from the nominal baud rate) of up to P % of a bit time (gross start-stop-distortion, see also Figure 2), assuming that each bit time is at least Q % of a nominal bit time (minimum signal element, see also Figure 2).

5.3.3 Character interval requirement

For data transmission the time between a start bit and both the next and the following start bit shall be not less than the nominal interval of 11 respective 22 bit times $- T$ % of a nominal bit time (character interval requirement, see also Figure 3).

5.3.4 Practical receive margin and character interval requirement

For data reception deviations from the nominal transition times of up to $\pm V$ % of a nominal bit time shall be tolerated (practical margin, see also Figure 4). Also the start bits of byte pairs and byte triples with a deviation of up to $- Y$ % of a nominal bit time from their nominal value of 11 respective 22 bit times shall be received correctly (character interval requirement, see also Figure 5).

5.3.5 Minimum signal element

For data reception start bits with a duration of $< W$ % of a nominal bit time shall be ignored (minimum signal element, see also Figure 6).

5.4 Byte format

An asynchronous serial bit (start-stop)-transmission in half duplex mode is used. The byte format is 1 start bit, 8 data bits, 1 bit for even parity and 1 stop bit.

5.5 Block format

5.5.1 Transmission interbyte gaps

In data transmission gaps between bytes are only allowed within the non accumulating bit time error budget of $< \pm P$ % of a nominal bit time (see also Figure 2).

5.5.2 Reception interbyte gaps

In reception any gap between bytes of greater than $+ P$ % of a nominal bit time may, any gap of grater 22 bit times shall be considered as the end of a telegram.

5.5.3 Idle time between telegrams

At the end of each telegram the receiver shall test for a minimum quiescent time (continuous mark state) of at least 11 bit times. This is required to clearly distinguish between a true isolated telegram and a section of longer telegram (see also Figure 8).

5.6 Telegram abort on collision

If a slave detects at the end of a mark level send bit a (voltage) space signal from its master it has to terminate its send telegram as soon as possible. A received continuous space signal from the master for > 11 bit times (break signal) shall stop the telegram send of a slave not later than 24 bit times after the start of such a break signal. For a software implementation of the byte transmission this requirement can be met by testing the received signal state either at the end of each mark state send bit or before the beginning of each start bit send. For a hardware implementation of the byte reception (UART) one can utilize the break status of such devices to detect such a state. For further details see annex D.

5.7 Telegram description

5.7.1 General

As a link layer the format class FT1.2 of EN 60870-5-1 and a telegram structure according to EN 60870-5-2 shall be used. For an example of a telegram and a simple readout dialog see annex F.

5.7.2 Data integrity

The parity bit and the checksum byte of the FT1.2 format class of the EN 60870-5-1 achieve a Hamming distance of 4 for data integrity class 2.

5.7.3 Telegram structure

The telegram structure is described in the EN 60870-5-2. All communication types of this standard may be used:

5.7.3.1 Normalisation (required)

Short telegram master to slave: SND_NKE. Answer: $E5. Note that this command shall only preset the internal "last received FCB-bit" and clear the optional selection bit. It shall not be used for any other kind of reset function.

5.7.3.2 Request for time critical data (required)

Short telegram master to slave: REQ_UD1. Answer: RSP_UD or $E5 if there are no time critical data pending or if such a function is not implemented in the terminal device (meter). The request for time critical may be used for an alarm poll since the link layer protocol of the EN 60870-5 does not support spontaneous alarms from the slaves.

NOTE This is optional in EN 1434-3. It is required for new slaves according to this standard to simplify future use of this function by masters.

5.7.3.3 Standard readout request (required)

Short telegram master to slave: REQ_UD2. Answer: RSP_UD.

5.7.3.4 Status request (required)

Short telegram master to slave: REQ_SKE. Answer: RSP_SKE. Note that the RSP_NKE might contain information on the status if the input buffer of the device (DFC-bit) and information about a request for time critical data.

5.7.3.5 Data send master to slave (required)

Long telegram master to slave: SND_UD. Answer: $E5.

5.7.4 Telegram coding

For the coding of the individual bytes of the telegrams see EN 60870-5.

5.7.5 Addressing

Address 0 is reserved for unconfigured slaves. Each unconfigured slave shall accept and answer all communication to this address.

Addresses 1 to 250 are used for primary addressing of slaves. Each slave shall accept and answer all communication to its primary address.

Address 251 is reserved for management communication with the primary master repeater (e.g. for physical and link layer management).

Address 252 is reserved.

Address 253 is reserved for secondary addressing. Each selected slave shall accept and answer all communication to this address. For selection and deselection of individual slaves or groups of slaves see the application layer for secondary adressing.

Address 254 is the address for test and diagnosis. Each slave shall accept and answer all communication to this address.

Address 255 is the broadcast address. Each slave shall accept and execute all communication to this address without answer.

5.7.6 Link layer time schedule

The time structure of various link layer communication types is described in EN 60870-5-1. The answer time between the end of a master send telegram and the beginning of the response telegram of the slave shall be between 11 bit times and (330 bit times + 50 ms). See Figure 8.

5.7.7 Telegram sequencing

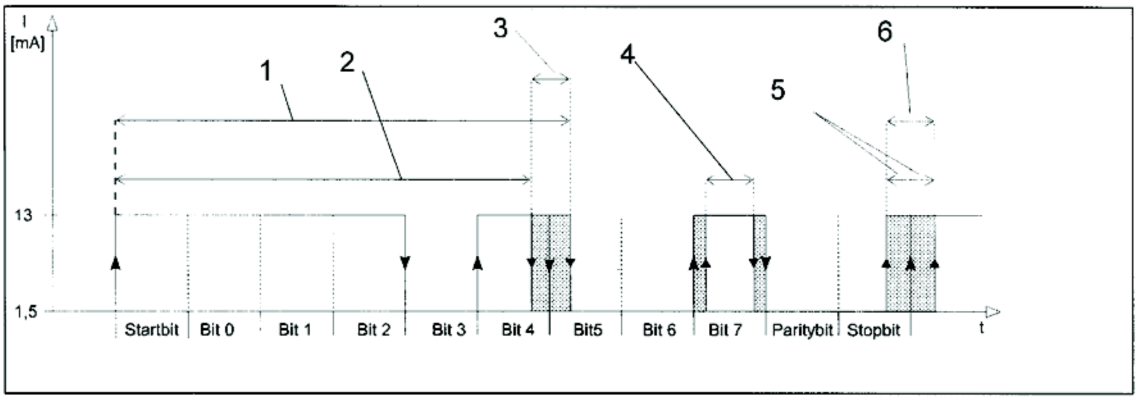
For the administration of long multi telegram messages and for acknowledged data transmission with incremental consequences (in contrast to the transmission of static values and parameters) the link layer protocol supports via a FCB-Bit (frame count bit) the administration of valid transfers of a telegram. For simple one telegram communication and absolute data contents (e.g. switch on) without incremental messages (e.g. toggle switch) the slave may simply ignore the FCB-bit of the master telegrams. For slaves with multiple primary addresses and FCB-administration a ”last FCB” bit shall be administered for each primary address separately. The same holds true for slaves which support both a primary address and addressing through a secondary address via address = 253 ($FD). Any valid SND_NKE to a given address shall clear this internal ”last FCB”-bit for this address. Note that the support of multi telegram both for SND_UD messages and for RSP_UD messages requires separate internal ”last FCB”-bits for each direction. Note that for REQ_UD2-telegrams a set FCV-bit and for a SND_NKE telegram a cleared FCV-bit and a cleared FCB-bit is required.

6 Tables and figures

The values and descriptions in the following table are taken from the ISO/IEC 7480:1991. U_I (unit interval) is an abbreviation for the nominal duration of a bit time.

Table 1 — Signal quality characteristics for slaves and masters

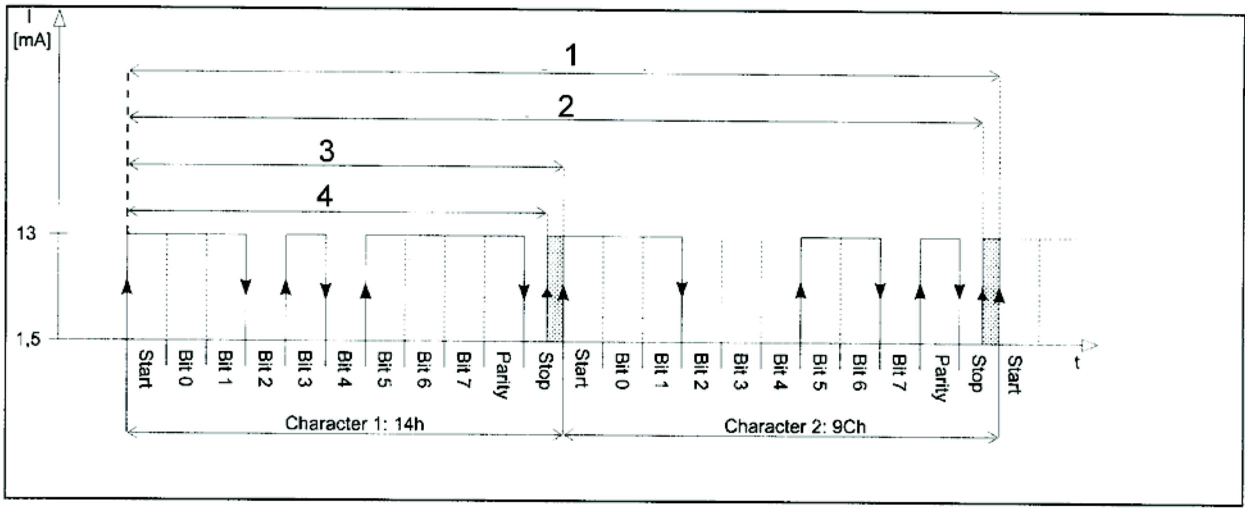
Direction	Fig.	Description	Symbol	Unit	Device	
					Master	Slave or Mini Master
Transmit	2	Synchronous start-stop distortion	N	%	≤ 5	≤ 8
	2	Gross start-stop distortion	P	%	≤ 7	≤ 16
	2	Minimum signal element	Q	% U_I	90	84
	3	Character interval requirement				
		Average: nominal reduced by	R	% U_I	≤ 8	≤ 10
		Averaged over	S	Char	2	2
		Minimum: nominal reduced by	T	% U_I	≤ 16	≤ 20
		Modulation rate accuracy	M	%	≤ 0,2	≤ 0,75
Receive	4	Practical margin	V	%	≥ 40	≥ 30
	6	Minimum signal element	W	% U_I	30	30
	5	Character interval requirement				
		Average: nominal reduced by	X	% U_I	20	25
		Averaged over	S	Char	2	2
		Minimum: nominal reduced by	Y	% U_I	40	50



Key

1 6 average bittimes + N% of one nominal bittime
  6 average bittimes + P% of one nominal bittime
2 6 average bittimes — N% of one nominal bittime
  6 average bittimes — P% of one nominal bittime
3 range permitted
4 Q% of a nom. bittime permitted
5 P% of a nom. bittime
6 range permitted

Figure 2 — Start stop distorsion (example for bit 4), minimum signal element (example for bit 7) (Transmit)



Key

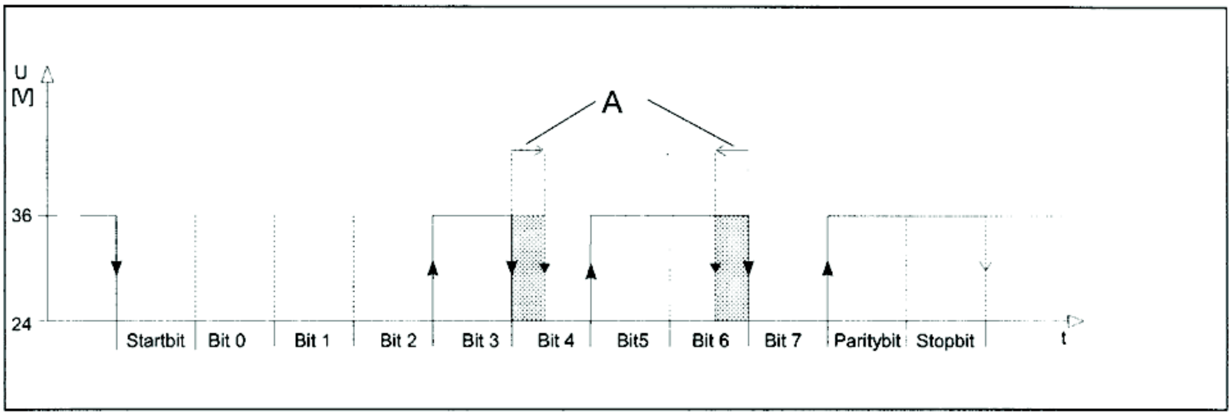
1 2 × (character length nominal.)

2 minimum averaged character length = 2 × nominal – T% of nominal. Bittime

3 charcter length nominal

4 min. character length = nom. – T% of nom. Bittime

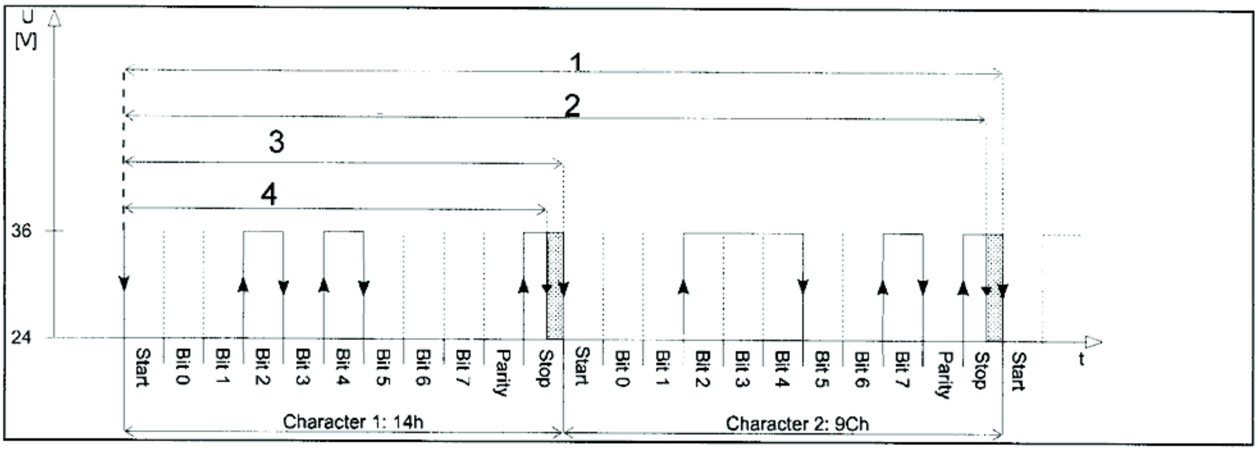
Figure 3 — Character interval requirement (Transmit)



Key

A shifting of falling slmope for V% of nominal bittlength

Figure 4 — Practical receive margin (example for two falling slopes)



Key

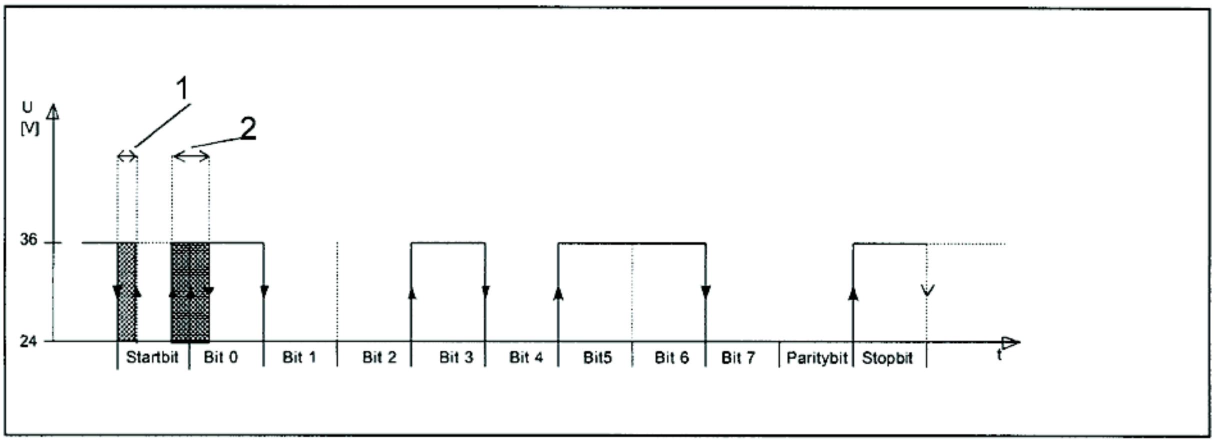
5 2 × (character length nominal.)

6 minimum averaged character length = 2 × nominal – Y% of nominal. Bittime

7 charcter length nominal

8 min. character length = nom. – Y% of nom. Bittime

Figure 5 — Character interval requirement (Receive)

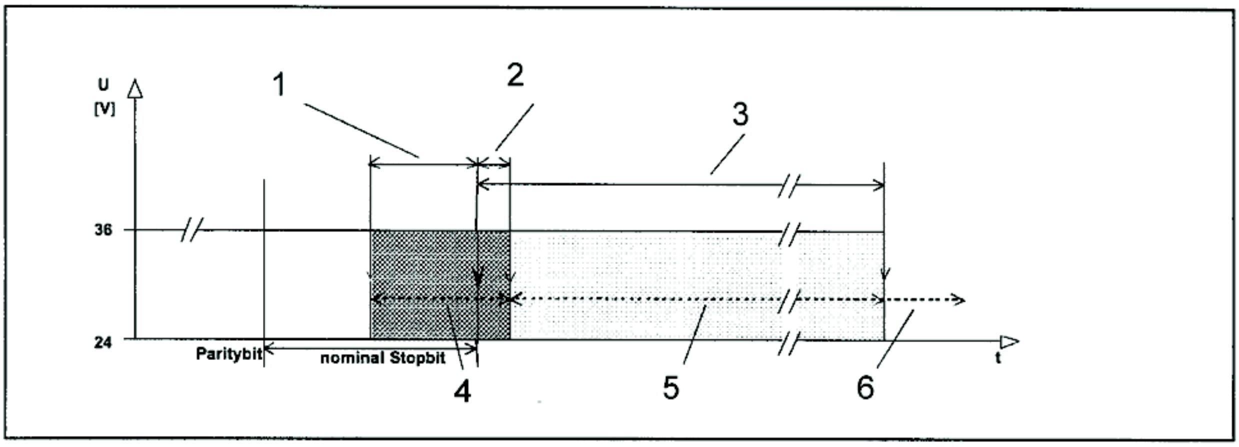


Key

1 Starbit with a duration < W% of a nominal bittime shall be ignored

2 Deviation up to +-V% of a nominal bittime shall be tolerated (any bit)

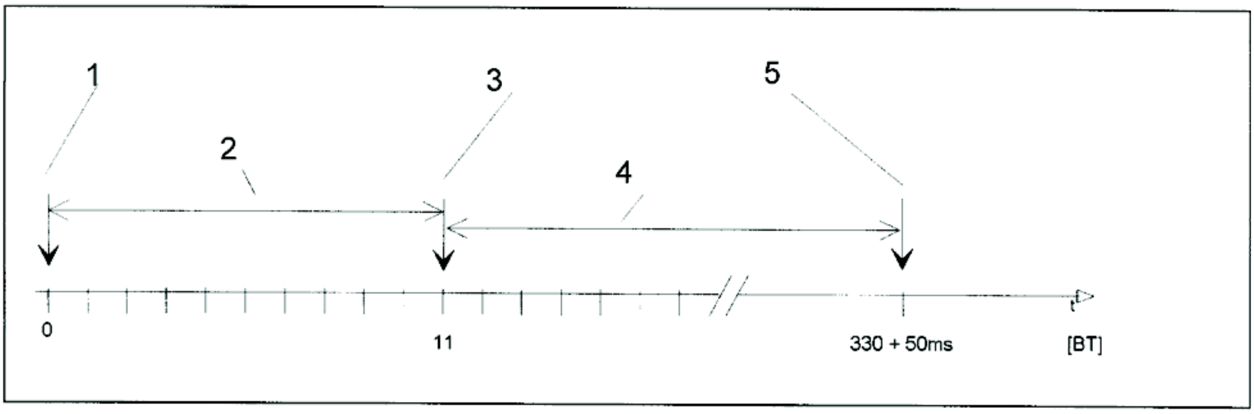
Figure 6 — Minimum duration start element (Receive)



Key

1 – Y% shall be tolerated
2 + P% shall be tolerated
3 max. 22 bit times may be tolerated
4 shall be accepted
5 may be detected as end of telegram
6 shall be detected as end of telegram

Figure 7 — Reception of telegram packets



Key

1 end of received telegram
2 slave has to check for continuous mark state (11 bit times)
3 earliest time to begin answer
4 period in which the slave may begin answer
5 latest time to begin answer

Figure 8 — Quiescent time after reception

Annex A
(informative)

Schematic implementation of slave

A slave can be implemented by a circuit similar to the following functional diagram.

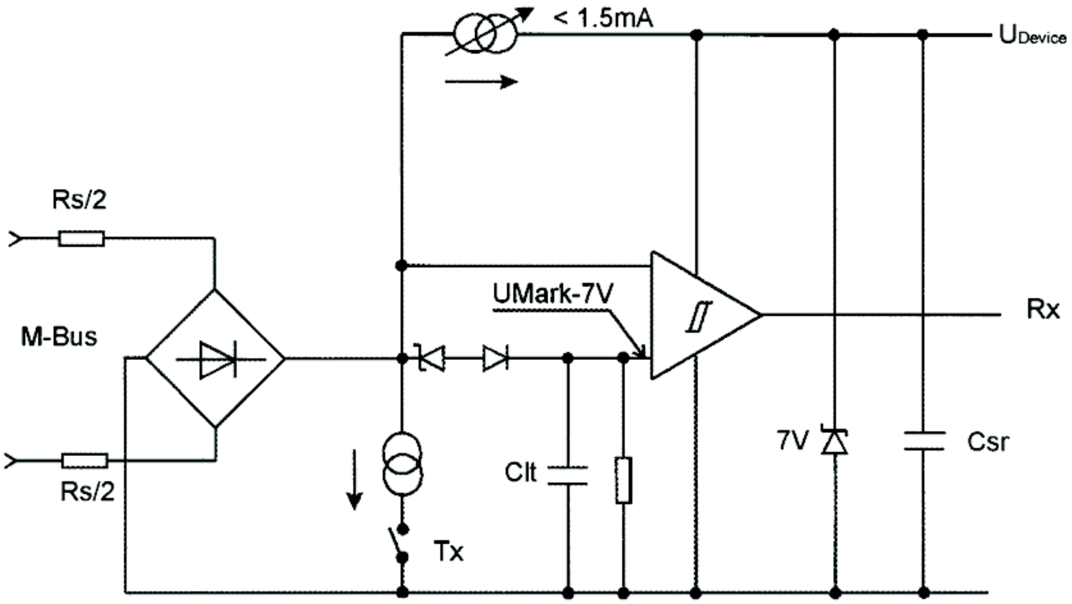
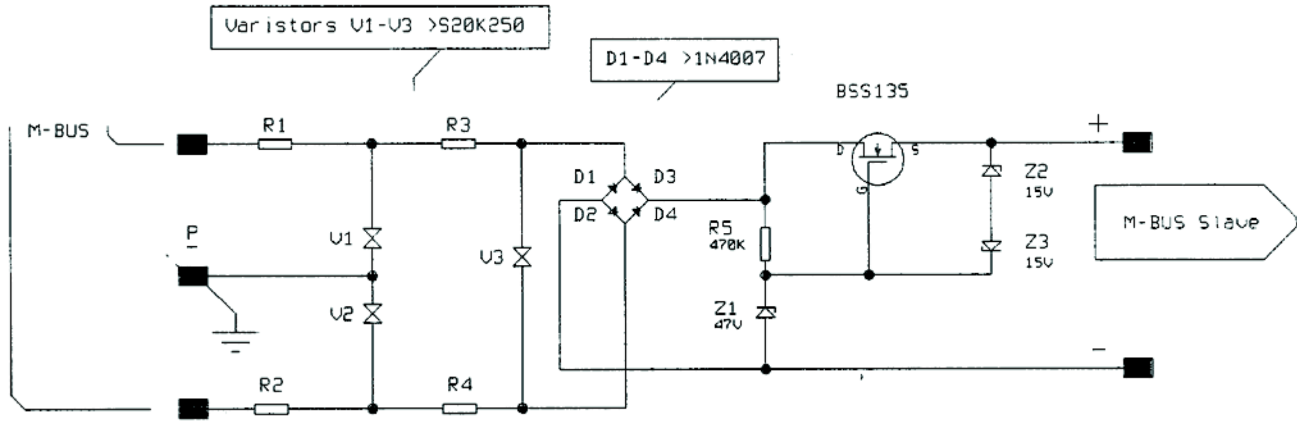


Figure A.1 — Slave transceiver

Annex B
(informative)

Protection against mains voltages

A slave can be reversibly protected by a circuit similar to the following diagram:



Key

P Protective Ground

Figure B.1 — Overvoltage protection for slave transceiver

Annex C
(informative)

Slave powering options

A standard slave can be operated with the following slave powering alternatives:

1) Fully battery powered

   In this case the readout frequency will be limited or the battery lifetime will depend on the readout frequency.

2) Fully bus powered

   In this case the readout frequency can be unlimited, but the slave function or the slave memory might be impaired by a bus voltage failure.

3) Battery/Bus powered with automatic switchover

   In this case unlimited readout frequency is possible and full meter functionality might be retained even without bus voltage.

4) For slaves with electrical connection to ground:

   Electrical) insulation (usually by optical methods) is required. Only the transceiver circuit is powered from the bus, the device itself is powered either from battery or from mains.

Annex D
(informative)

Slave collision detect

Collisions between transmitting slaves can occur during slave search activities by the master. Very light collisions of (22 … 33) mA, which are equivalent to 2 or 3 transmitting slaves, are electrically undetectable by master and slave. New master hardware with double current detect can detect light collisions of (20 … 200) mA and then transmit a break (50 ms space) on the bus. The slave can detect medium collisions of (70 … 500) mA, if this is a collision between a mark and a space and if the slave supports this feature. Heavy collisions of (90 … 5 000 mA) will have the effect of a break down of the bus voltage (power fail in the slave) and possibly a shortcircuit in the master.

To avoid these consequences of (heavy) collisions new master have the feature of double current detect with break signalling and switching off the bus in overcurrent states. There are some means for the slaves to detect collisions and then stop transmitting:

1) Software based UART´s can test at the end of each Mark-Send-Bit whether the input is really a mark. This guarantees a very fast detection of collisions, is simple to implement and is strongly recommended for pure software UART.

2) A variation of the preceeding method is to test whether the bus voltage is mark directly before the transmission of each start bit. This is simple for a software UART, but very tricky for a hardware UART and requires a master sending a break on collision detect.

3) A simple method for unbuffered hardware UART, but tricky for buffered hardware UART, compares the transmitted with the received byte.

4) Another method, which requires a master with break collision detect, is a hardware UART with break detect.

Annex E
(informative)

Cable installation

E.1 General

The following segment types will ensure safe physical layer communication. A cabling of either a shielded (typically 4 × 0,8 mm diam./ 0,5 mm^2) telephone type or a standard mains type (1,5 mm^2) have been investigated. For telephone cabling with 0,6 mm diameter wires either the maximum distance or the maximum number of devices has to be halved. It should be noted that the shielding is connected only to the master ground, but is open at the terminal side for DC and low frequency signals.

E.2 Type A: small in house installation

E.2.1 Description

Distance (resistive cable length) ≤ 350 m.

Total length of segment wiring: ≤ 1 km.

Cable type: telephone type, 0,8 mm diam. shielded, copper cross section 0,5 mm^2, resistance < 30 Ohm.

E.2.2 Usage

For maximum number of devices:	max. 250 Unit Loads @ 9 600 Baud.
For maximum communication speed:	max. 64 Unit Loads @ 38 400 Baud.

E.3 Type B: large in house installation

E.3.1 Description

Distance (resistive cable length) ≤ 350 m.

Total length of segment wiring: ≤ 4 km.

Cable type: telephone type, 0,8 mm diam. shielded, copper cross section 0,5 mm^2, resistance < 30 Ohm Usage.

E.3.2 Usage

For maximum number of devices:	max. 250 Unit Loads @ 2 400 Baud.
For maximum communication speed:	max. 64 Unit Loads @ 9 600 Baud.

E.4 Type C: small wide area net

E.4.1 Description

Distance (resistive cable length) ≤ 1 km.

Total length of segment wiring: ≤ 4 km.

Cable type: telephone type, 0,8 mm diameter shielded, copper cross section 0,5 mm^2, resistance < 90 Ohm.

E.4.2 Usage: maximum of 64 unit loads @ 2 400 Baud

E.5 Type D: large wide area net

E.5.1 Description

Distance (resistive cable length) ≤ 3 km.

Total length of segment wiring: ≤ 5 km.

Cable type: mains wiring, cross section 1,5 mm^2, resistance < 90 Ohm.

Special shielded cable is recommended for this application.

E.5.2 Usage: maximum 64 unit loads @ 2 400 Baud

E.6 Type E: mini installation (meter cluster)

E.6.1 Description

Distance (resistive cable length) ≤ 50 m.

Total length of segment wiring: ≤ 50 m.

Cable type: telephone type, 0,8 mm diam. shielded, copper cross section 0,5 mm^2, resistance < 5 Ohm.

E.6.2 Usage: maximum 16 Unit Loads @ 2 400 Baud

Annex F
(informative)

Protocol examples

F.1 Startup

After fully powering up the master and after the startup delay of the slaves of 3s (max.) the master normalize the link layer of all slaves by sending a “SND-NKE”-type telegram to the broadcast address “FFh” consisting of the bytes: 1040FF3F16 (10h= Start fixed length, C=40h: Send o Reply, Reset, A=FFh Broadcast, No Reply, 3Fh=Checksum, 16h= End). Taking into account the start bit (0), the stop bit (1) the even parity bit and the bit sequence of LSB first the total bit sequence is:

00000100011 00000001011 01111111101 01111110001 0011100011.

F.2 Slave (meter) readout

A meter with address A=1 can be read via the following dialog:

Master to slave

REQ_UD2 (Request normal i.e. not time critical data) 105B015C16.

After a delay of between 11 bit times and 330 bit times +50ms:

Slave to master:

RSP_UD (Respond with user data C=08h): 68L1L26808CIxxyyzzCS16.

Where L1=L2 signal the number of application bytes. In this example with application bytes xxyyzz L1=L2=6 since the length information includes the C, A and CI bytes. The CI signals the control information field which selects the application layer and its function and CS is the checksum.

For further examples and error handling of the link layer see prEN 13757-3, EN 1434-3 or EN 608750-5-1 and EN 60870-5-2.

Bibliography

[1] EN 1434-3:1997, *Heat meters — Part 3: Data exchange and interfaces.*

[2] EN 13757-1:2002, *Communication systems for meters and remote reading of meters — Part 1: Data exchange.*

[3] EN 13757-3:2004, *Communication systems for and remote reading of meters — Part 3: Dedicated application layer.*

[4] prEN 13757-4, *Communication systems for and remote reading of meters — Part 4: Wireless meter readout.*

[5] EN 60870-5-1:1993, *Telecontrol equipment and systems — Part 5: Transmission protocols — Section 1: Transmission frame formats (IEC 60870-5-1:1990).*

[6] EN 60870-5-4:1993, *Telecontrol equipment and systems — Part 5: Transmission protocols — Section 4: Definition and coding of application information elements (IEC 60870-5-4:1993).*

[7] EN 62056-21:2002, *Electricity metering — Part 21: Data exchange for meter reading, tariff and load control — Direct local data exchange (IEC 62056-21:2002).*

[8] ISO/IEC 646:1991, *Information technology — ISO 7-bit coded character set for information interchange.*

[9] ISO/IEC 7480:1991, *Information technology — Telecommunications and information exchange between systems — Start-stop transmission signal quality at DTE/DCE interfaces.*

[10] ISO/IEC 7498-1:1994, *Information technology — Open Systems Interconnection — Basic reference model: The basic model.*