CEN TC 294

Date: 2000-02-15

TC 294 WI 006

CEN TC 294

Secretariat: AFNOR

Meter Communication

Twisted Pair Baseband (M-Bus)

Physical and Link Layer

ICS:

Descriptors:

Document type: European Standard
Document subtype:
Document stage: Working Document
Document language: E

Contents

Foreword

This document has been prepared by CEN /TC 294, "Systèmes de relevés à distance".

This document is a draft ocument.

Introduction

The physical and link layer parameters for baseband communication over twisted pairs has first been described in EN1434-3:1997 ("M-Bus") for heat meters. This standard is a compatible and interworking update of a part of EN1434-3:1997 and includes also other measured media (water, gas, heat cost allocators), the master side of the communication and newer technical developments. Note that the EN1434-3:1997 covers also other communication techniques.

It can be used with various application layers especially the application layer of ENxxxxx and EN13757.

1 Scope

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

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

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.

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

EN 60870-5-1-1:1992?, *Telecontrol equipment and systems. Part 1: General considerations. Section One: General principles*

EN 60870-5-1-2:1992?, *Telecontrol equipment and systems. Part 1: General considerations. Section Two: Guide for specifications*

EN 60870-5-2:1992?, *Telecontrol equipment and systems - Part 2: Operating conditions*

3 Definitions

1 UL (One unit load) is defined as a maximum mark state current of 1.5mA.

4 Physical Layer Specifications

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

4.1 Electrical Requirements Slave

4.1.1 Master to Slave Bus Voltages

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

Voltage range for meeting all specifications: +-(12V..42V)

The Bus voltage at the slave terminals in mark-(quiescent) state of master slave communication (=UMark) shall be +-(21..42V) .

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 1s.

The stored voltage maximum UMark may drop in 50ms by not more than 0.2V for all voltages between 12V and UMark.

Bus voltage Mark/Space state for master slave communication

Space: UBus< UMark-8.2V

Mark: UBus >= UMark-5.7V

Maximum space state time 50ms

Maximum space state duty cycle: 0.92

4.1.2 Slave bus current and multiple unit loads

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.

4.1.2.1 Mark state bus current of a slave device

The mark state current IMark shall be <=N unit loads,

4.1.2.2 Variation of the mark state current over bus voltage

For bus voltages in the range of +-(12V..42V) a voltage variation of 1..15V shall not change the bus current by more than N*3uA/V.

4.1.2.3 Short term variation of the mark state current

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

4.1.2.4 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.

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

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

4.1.2.6 Slow start

For any bus voltage in the range of 0..+-42V the bus current shall be limited to <= N*UL.

4.1.2.7 Fast change

After any bus voltage change the bus current shall be <= N*UL within 1ms.

4.1.2.8 Space-Send current

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

ISpace=IMark+(11..20)mA.

4.1.2.9 Input capacitance at the slave terminals: <= 0.5nF

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

4.1.2.10 Startup delay

In case of a bus voltage drop below 12V for longer than 0.1s the recovery time after applying an allowed mark state voltage until reaching full communication capabilities shall be less than 3s.

4.1.2.11 Galvanic Isolation

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

4.1.2.12 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: 1min) the slave interface can withstand mains voltages of 230V +10% and 50Hz or 60Hz and that afterwards all specifications are met again. This mains protection function is recommended for all mains operated terminal devices. For possible implementations see appendix B.

4.1.3 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 50ms. Note that this is true for any asynchronous protocol with 5-8 data bits (with or without a parity bit) for any baud rate of at least 300 baud, including a break signal of 50ms. It is also true for many synchronous protocols with or without bit coding.

4.2 Electrical Requirements Master

4.2.1 Parameters

4.2.1.1 Max current (IMax)

A master for this physical layer is characterized by its maximum current IMax. For all bus currents between zero and IMax it shall meet all functional and parametric requirements. For example a maximally loaded segment with up to 250 slaves with 1 UL each (375mA) plus an allowance for one slave with a short circuit (+100mA) plus the maximum space send current (+20mA) an IMax >= 0.5A is required.

4.2.1.2 Max allowable voltage drop (Ur)

The max. voltage drop Ur (>0V) is defined as the minimum space state voltage minus 12V. Ur 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.

4.2.1.3 Max baudrate (BMax)

Another characterisation of a master is the maximum baud rate BMax up to which all specifications are met. The minimum baudrate is always 300 Baud.

4.2.1.4 Application description

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

4.2.2 Function types

4.2.2.1 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 baudrates of 300..BMax. No bit time recovery is possible. Hence a simple level converter can not be used as a repeater.

4.2.2.2 Intelligent level converter

An intelligent level converter can perform space bit time recovery for any asynchronous byte protocol at its maximum baudrate BMax. Other baudrates BMax/L (L=2..LMax) are allowed, but bit time recovery can not be guaranteed for these other baudrates. Such a level converter can be used as a physical layer repeater for its maximum baudrate.

4.2.2.3 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 baudrates.

4.2.2.4 Gateway

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

4.2.3 Requirements

4.2.3.1 Mark state (quiescent state) voltage

For currents between 0..IMax: UMark= (24V+Ur)..42V

4.2.3.2 Space state (signal state) voltage

USpace <UMark-12V, but >=12V+Ur

4.2.3.3 Bus short circuit

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

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

4.2.3.4 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 (CLoad selected from the E12 value series):

Baudrate 300 Baud: CLoad= 1.5µF:

Baudrate 2400 Baud: CLoad=1.2µF

Baudrate 9600 Baud: CLoad=0.82 µF

Baudrate 38400 Baud: CLoad= 0.39 µF

4.2.3.5 Effective Source Impedance

The voltage drop of the bus voltage for a short (<50ms) increase of the bus current by 20mA shall be <=1.2V.

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

4.2.3.7 Data detection current (Reception of slave current pulses)

Bus current <=Bus idle current + 6mA: Mark state receive

Bus current >=Bus idle current + 9mA: Space state receive

Measurement with current pulses of <50ms, duty cycle <0.92

4.2.3.8 Reaction at large data currents (collision)

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

4.2.3.9 Galvanic isolation

The isolation resistance between any bus terminal and all metal parts accessable without violating seals shall be >1MOhm. The test voltage is 500V. 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 resp. signal lines. For mains powered masters the appropriate safety rules apply.

4.2.3.10 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 (40-60%) with respect to ground. This requirement is only valid for ground based systems.

4.3 Electrical Requirements Mini-Master

4.3.1 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.

BMax: 2400 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.

4.3.2 Requirements

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

4.3.2.1 Minimum transition slopes

For a load capacitance of 75nF: 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 tmax <=50µs.

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

4.4 Repeaters

4.4.1 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.

4.4.2 Additional Requirements

4.4.2.1 Isolation

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

4.4.2.2 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 baudrate(s) or may be restricted to certain byte formats or link layers.

4.5 Burst and Surge requirements

A device according to this standard must fulfill at least the following burst and surge requirements according to EN61000-4-4 (1995) and EN61000-4-5 (1995) 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 EN1434-3 due to field experience.

4.5.1 Requirements for devices intended for domestic use

Burst test voltage: 1kV (Severity class 2)

4.5.2 Requirements for devices intended for industrial use

Burst test voltage: 1kV (Severity class 2)

Surge test voltage: 1kV (Severity class 2)

5 Link Layer (Master and Slave)

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

5.1 Baudrate

5.1.1 Required Baudrate

300 Baud shall be supported

5.1.2 Recommended additional Baudrates:

2 400 or 9 600 Baud are recommended

5.1.3 Special Baudrates:

By special arrangement between a net operator and a meter manufacturer also one or several of the following baudrates could be used: 600, 1200, 4800 Baud, 19 200 or 38 400 baud.

The total segment size and the number of connected slaves limits the technically safe maximum baudrate. (See cable installation section in appndix D).

5.1.4 Baud rate after reset

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

5.1.5 Baud rate set

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

5.1.6 Autospeed mode

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

5.1.7 Transmit baudrate accuracy

The transmission baudrate 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 +-M% of the nominal baudrate (see Table 1).

5.2 Bit position

5.2.1 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 baudrate) of up to N% of a bit time (Synchronous start-stop-distortion, see also Fig. 1).

5.2.2 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 baudrate) of up to P% of a bit time (gross start-stop-distortion, see also Fig. 1), assuming that each bit time is at least Q% of a nominal bit time (minimum signal element, see also Fig. 1).

5.2.3 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 Fig. 2).

5.2.4 Practical Receive margin and character interval requirement

For data reception deviations from the nominal transition times of up to +-V% of a nominal bit time shall be tolerated (practical margin, see also Fig. 3). 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 rsp. 22 bit times shall be received correctly (character interval requirement, see also Fig. 4).

5.2.5 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 Fig. 5).

5.3 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.

5.4 Block format

5.4.1 Transmission interbyte gaps

In data transmission gaps between bytes are only allowed within the non accumulating bit time error budget of < +-P% of a nominal bit time (see also Fig. 1).

5.4.2 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.

5.4.3 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 Fig. 7).

5.5 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.

5.6 Telegram description

5.6.1 General

As a link layer the format class FT1.2 of EN60870-5-1 and a telegram structure according to EN60870-5-2 is used.

5.6.2 Data integrity

The parity bit and the checksum byte of the FT1.2 format class of the EN60870-5-1 achieve a Hamming distance of 4 for data integrity class 2.

5.6.3 Telegram structure

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

5.6.3.1 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.

5.6.3.2 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 EN60870-5 does not support spontaneous alarms from the slaves. Note: This is optional in EN1434-3. It is required for new slaves according to this standard to simplify future use of this function by masters.

5.6.3.3 Standard readout request (required)

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

5.6.3.4 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.

5.6.3.5 Data send master to slave (required)

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

5.6.4 Telegram coding

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

5.6.5 Addressing

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

Addresses 1-250 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.

5.6.6 Link layer time schedule

The time structure of various link layer communication types is described in EN60870-5-1. 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 + 50ms). See Figure 7.

5.6.7 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 inkremental 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/IEC7480 (1991). UI (unit interval) is an abbreviation for the nominal duration of a bit time.

Tab. 1 : Signal quality characteristics for slaves and masters

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

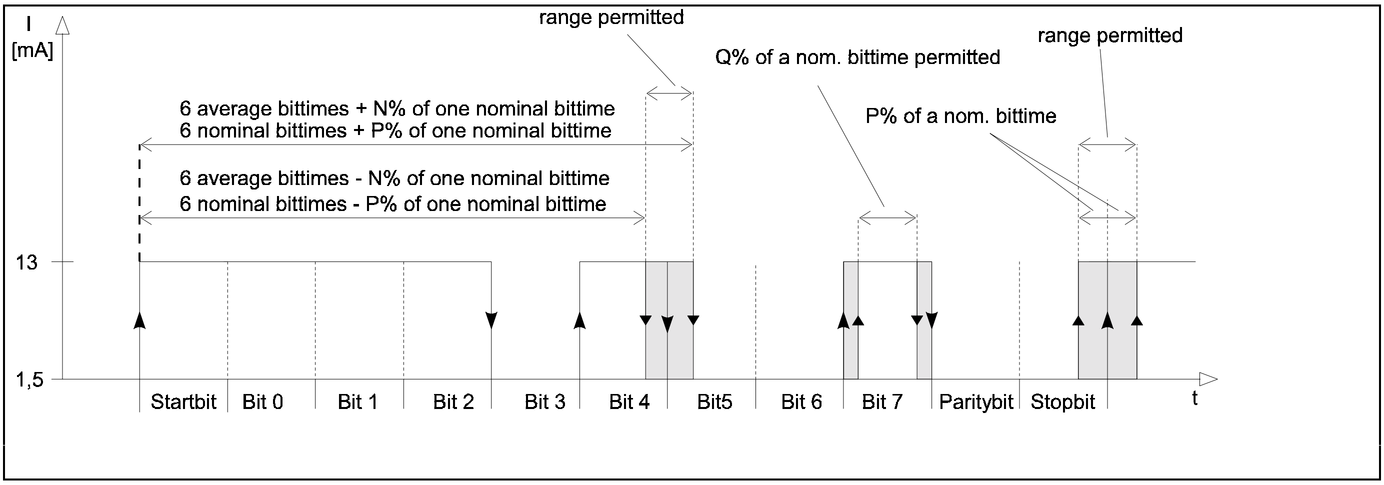


Fig. 1: Start stop distortion (example for bit 4), minimum signal element (example for bit 7) (Transmit)

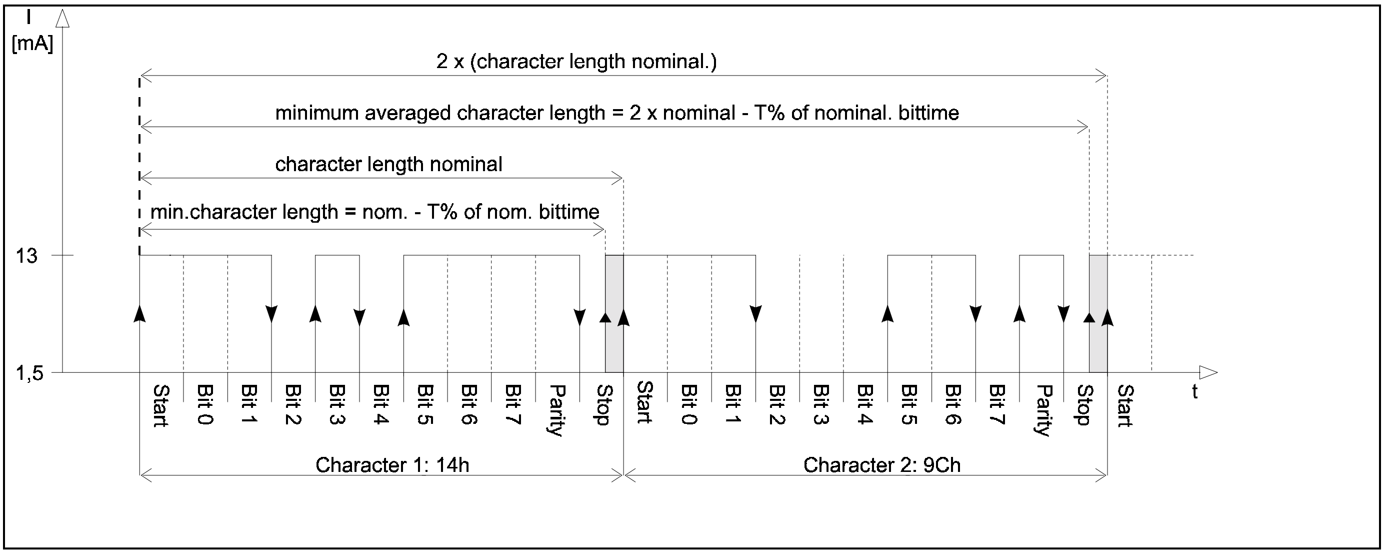


Fig. 2: Character interval requirement (Transmit)

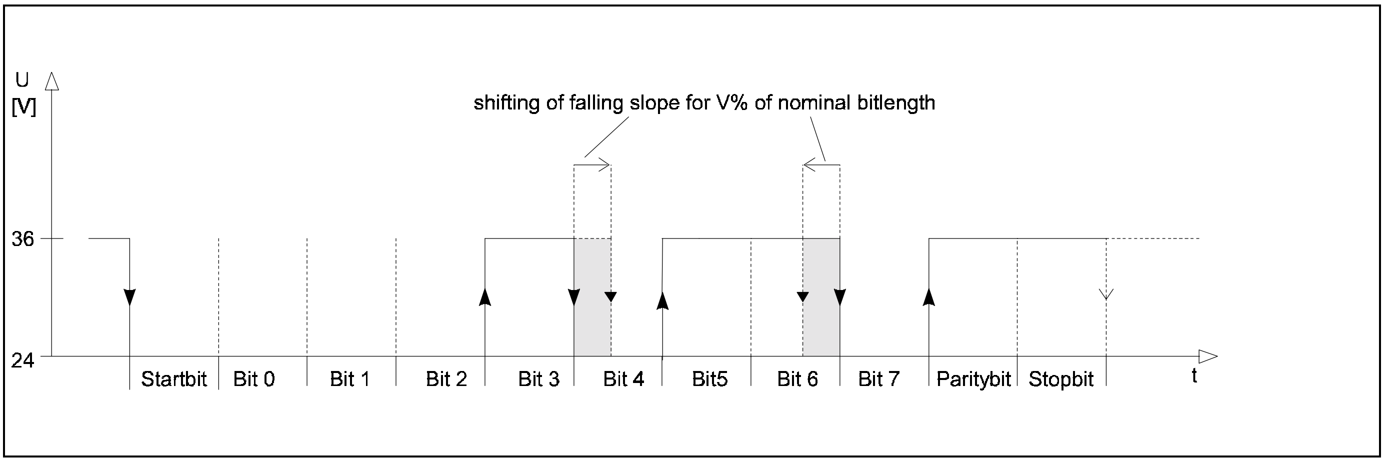


Fig. 3: Practical receive margin (example for two falling slopes)

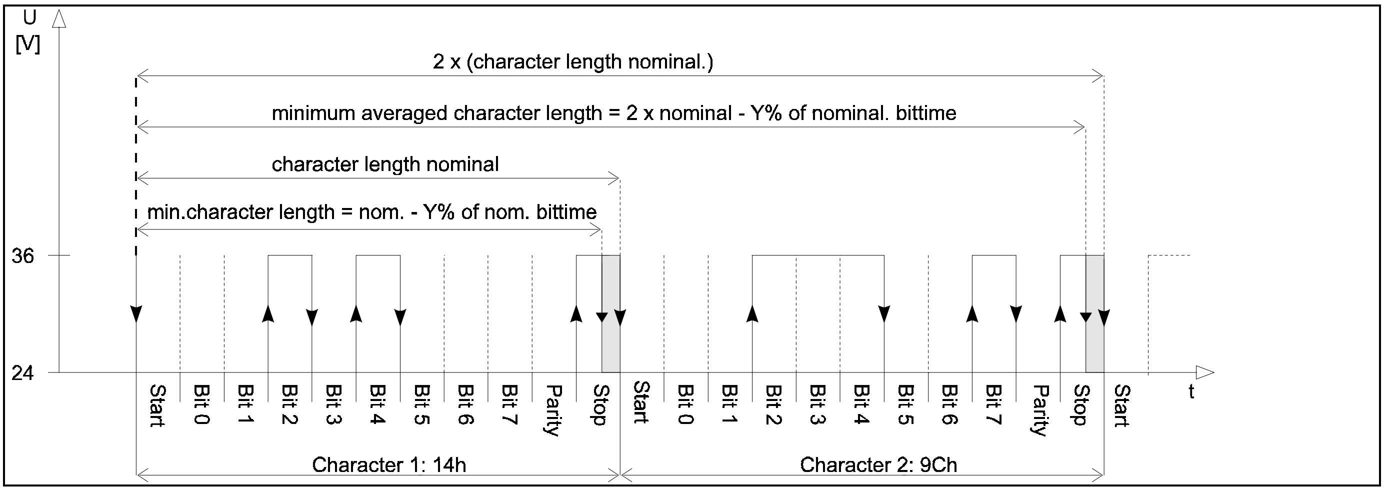


Fig. 4: Character interval requirement (Receive)

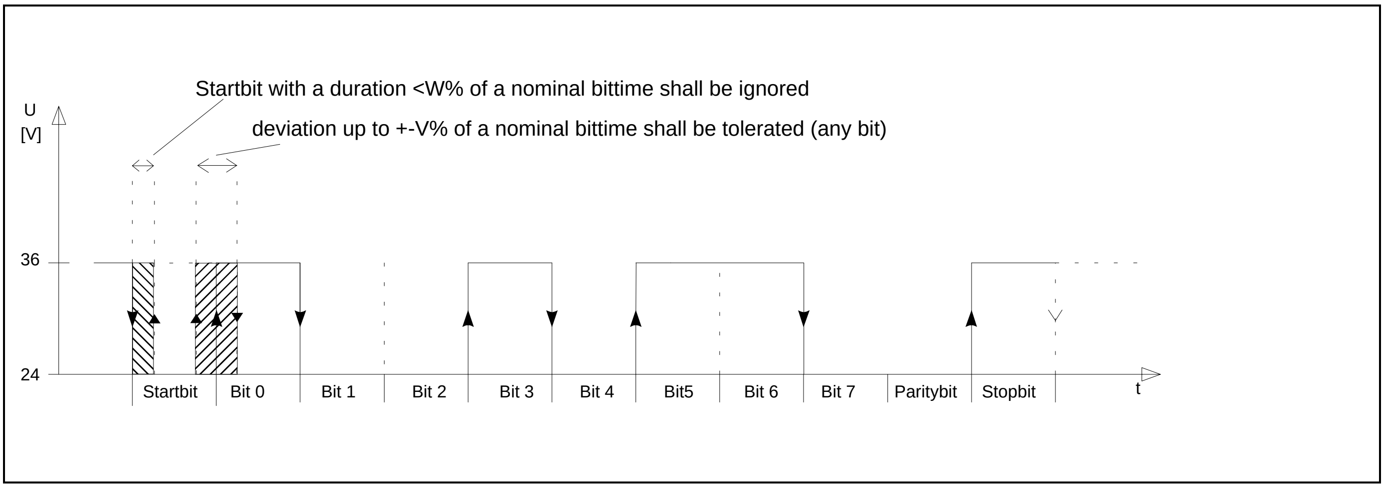


Fig. 5: Minimum duration start element (Receive)

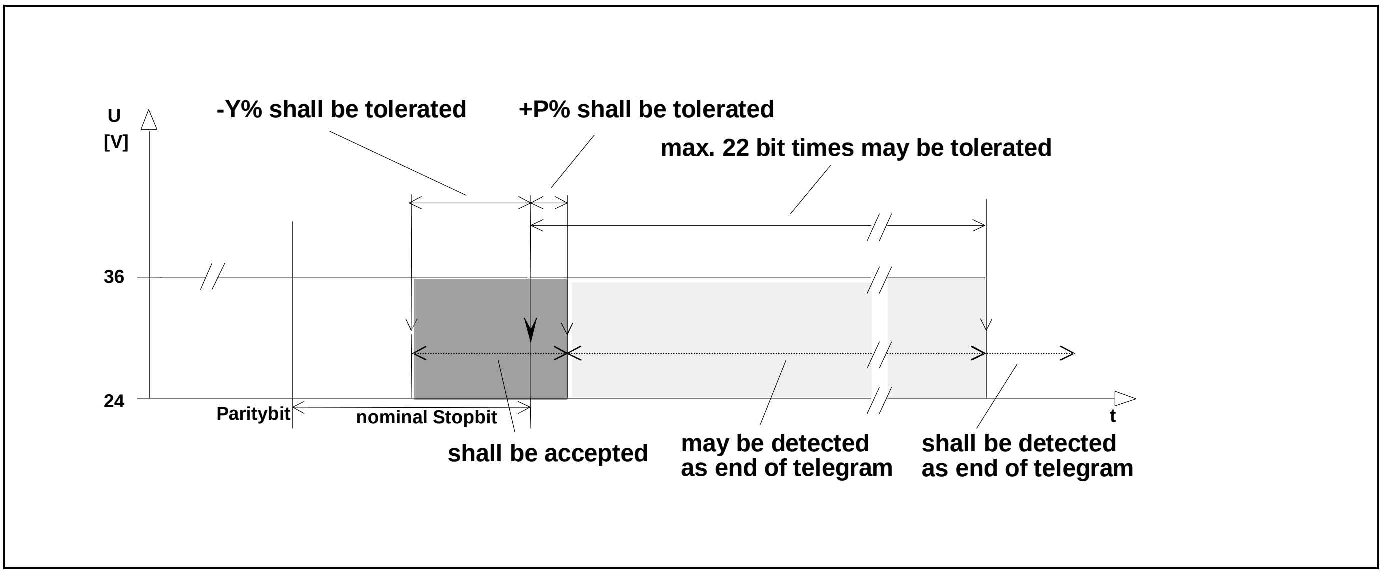


Fig. 6: Reception of telegram packets

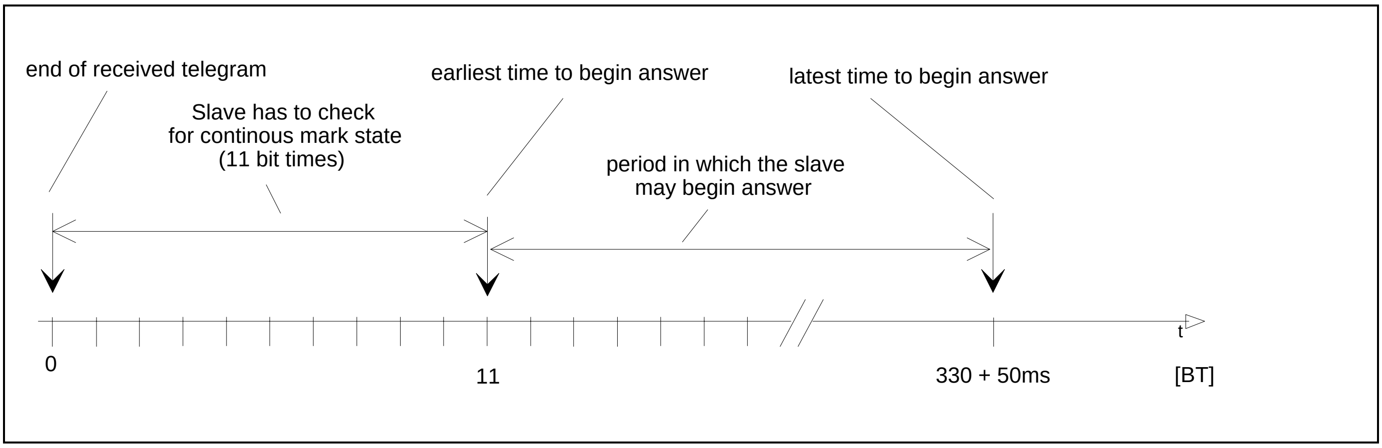
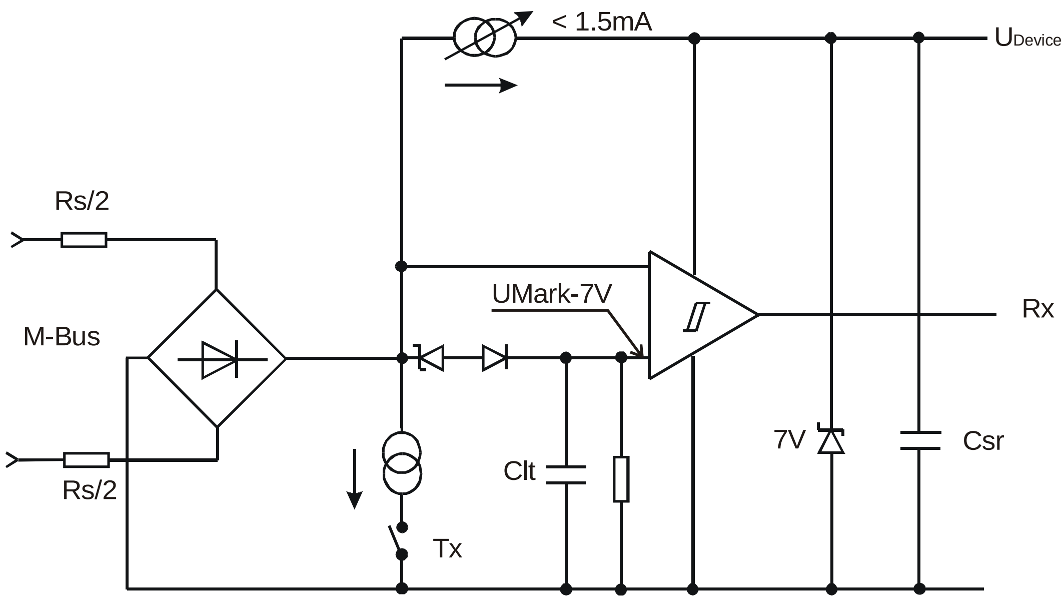


Fig. 7: quiescent time after reception

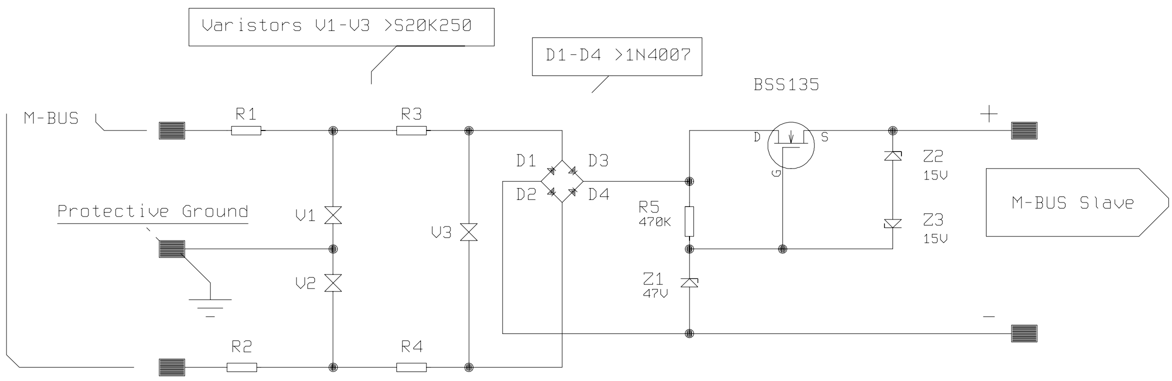
Appendix A (Informative): Schematic implementation of slave

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



Appendix B (Informative): Protection against mains voltages

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



Appendix 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 must be powered either from battery or from mains.

Appendix D: (Informative) Cable Installation

The following segment types will ensure safe physical layer communication. A cabling of either a shielded (typically 4*0.8mm diam./0.5mm²) telephone type or a standard mains type (1.5mm²) have been investigated. For telephone cabling with 0.6mm diameter wires either the maximum distance or the maximum number of devices has to be halved. Note that the shielding shall be connected only to the master ground, but must be open at the terminal side for DC and low frequency signals.

Type A: Small in House installation

1.) Description

Distance (resistive cable length) <=350 m

Total length of segment wiring: <=1 km

Cable type: telephone type, 0.8mm diam. shielded, copper cross section 0.5mm², resistance < 30 Ohm

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

Type B: Large in House installation

1.) Description

Distance (resistive cable length) <=350 m

Total length of segment wiring: <=4 km

Cable type: telephone type, 0.8mm diam. shielded, copper cross section 0.5mm², resistance < 30 OhmUsage

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

Type C: Small wide area net

1.) Description

Distance (resistive cable length) <=1 km

Total length of segment wiring: <=4 km

Cable type: telephone type, 0.8mm diam. shielded, copper cross section 0.5mm², resistance < 90 Ohm

2.) Usage: Maximum of 64 unit loads @ 2 400 Baud

Type D: Large wide area net

1.) Description

Distance (resistive cable length) <=3 km

Total length of segment wiring: <=5 km

Cable type: mains wiring, cross section 1.5mm^2, resistance < 90 Ohm.

Special shielded cable is recommended for this application.

2.) Usage: Maximum 64 unit loads @ 2 400 Baud

Type E: Mini installation (meter cluster)

1.) Description

Distance (resistive cable length) <=50 m

Total length of segment wiring: <=50 m

Cable type: telephone type, 0.8mm diam. shielded, copper cross section 0.5mm^2, resistance < 5 Ohm

2.) Usage: Maximum 16 Unit Loads @ 2 400 Baud