Open Metering System Specification

Requirements for Wired M-Bus

Annex P to
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Contents

Document History 2
Contents 3
Tables 5
Figures 5
P.1 General 6
P.1.1 Scope 6
P.1.2 Reference 6
P.2 Normative 7
P.2.1 Physical Layer 7
P.2.1.1 Wiring rules 7
P.2.1.2 SC Charge / Discharge 7
P.2.1.3 Inrush Current 7
P.2.1.4 Rise and Fall Times 7
P.2.1.5 Identification of the Unit Loads 7
P.2.1.6 Switch-on Process 8
P.2.1.7 Upper Limit for Voltage Variation 8
P.2.1.8 Break Detection 9
P.2.1.9 Logical Slave Disconnect 9
P.2.2 Link layer 10
P.2.2.1 Baud rates 10
P.2.2.2 Change of Primary and Secondary Address 10
P.2.2.3 Special Primary Addresses FEh and FFh 10
P.2.2.4 Two or More Logical M-Buses in One Hardware Environment 11
P.2.2.5 Datagram Detection 12
P.2.2.6 Repetitions 14
P.2.2.6.1 Slave Behaviour 14
P.2.2.6.2 Master Behaviour 14
P.2.2.7 Secondary addressing 14
P.2.3 Networking Layer / Secondary Addressing 14
P.2.3.1 Enhanced Selection 14
P.2.3.2 Determination of Addresses in Adapters 14
P.2.4 Application Layer 16
P.2.4.1 Selection of Application Data 16
P.2.4.2 Identification of a Meter Type in the Master 16
P.2.4.3 Minimum Communication Capabilities for Slaves 16
P.2.4.4 Commands for Communication If Applicable 16

P.2.4.5 Table with CI-Fields 16
P.2.4.6 New Device Type for Wired Adapters....16
P.3 Informative 17
P.3.1 Physical Layer....17
P.3.1.1 Cabling....17
P.3.1.1.1 Cable Types....17
P.3.1.1.2 Topology 17
P.3.1.1.3 Minimum Slave M-Bus Voltage 18
P.3.1.1.4 Transmission of Remaining Energy in Battery for Communication 22
P.3.2 Link Layer 23
P.3.2.1 Baud Rates 23
P.3.2.2 Functionality of SND-NKE 23
P.3.2.3 Preserving Communication Budget 23
P.3.3 Networking Layer / Secondary Addressing....25
P.3.3.1 Repetitions....25
P.3.3.1.1 Secondary Address Search (Slave Select)....25
P.3.3.1.2 Deselection 25

Tables

Table P.1 - UL ranges 8
Table P.2 - Required baud rate support 10
Table P.3 - Example for minimum requirements 24

Figures

Figure P.1 - Voltage variation 9
Figure P.2 - Quiescent time requirements for correct decodable datagram 12
Figure P.3 - Quiescent time requirements for disturbed messages 13
Figure P.4 - Generation of 8-digit identification number 15
Figure P.5 - Topology variants 18
Figure P.6 - M-Bus voltage 19
Figure P.7 - M-Bus states 21
Figure P.8 - Communication depot 24

P.1 General

P.1.1 Scope

This document describes the Open Metering System requirements for the Wired M-Bus. The Wired M-Bus is normatively represented in the EN 13757-2, -3 and -7 standard. During application of the EN 13757 standard, a certain amount of scope for interpretation or design freedom is offered. Among other things, this factor applies to the coding of the data within the application layer.

Therefore a number of different M-Bus datagrams from different manufacturers exist, with partially identical content. Because of this, problems often arise during the interpretation of datagram data in processing by readout systems or readout programs.

The specifications and standardizations in this document should contribute to increase the interoperability of Wired M-Bus products and minimise or solve existing problems.

This annex contains a normative (P.2) and an informative (P.3) part.

P.1.2 Reference

References to other documents are marked with square brackets. They are defined in Volume 1 [OMS-S1].

[EN 50441:2012] Cables for indoor residential telecommunication installations

P.2 Normative

P.2.1 Physical Layer

P.2.1.1 Wiring rules

Shielding shall be only connected to the protective earth on the master side and not at any slave.

The M-Bus lines shall not be coupled with ground / earth or any other voltage potential.

P.2.1.2 SC Charge / Discharge

As the master in the M-Bus system modulates the voltage, the slaves have to detect one threshold voltage for determining between logic high and low state of the bus voltage. Because of possible long term changes of the bus voltages and a wide span of allowed bus voltages, the threshold has to be determined dynamically. This can be done by storing the threshold voltage in a capacitor as reference.

The capacitor shall be sized to meet the following conditions:

- Charge: Voltage shall increase at 25 to 500 V/s
- Discharge: Voltage shall decrease at 0,5 to 15 V/s
- Ratio between charge and discharge speeds shall be > 30

NOTE: On best practice solutions for the usual slave transceiver devices has resulted in a 100 nF – 330 nF storage capacitor.

P.2.1.3 Inrush Current

The inrush current is the current flowing into a slave device within 1 µs after powering the bus to any allowed voltage level and shall be <100 mA..

P.2.1.4 Rise and Fall Times

The following limits on rise and fall times of the voltage modulation apply:

- < 75 V/µs (test condition: no load)
- < half of a bit time (test condition: see [EN13757-2:2018], 4.3.3.4)

P.2.1.5 Identification of the Unit Loads

The number of unit loads (UL) shall be listed in the data sheet. Additionally it shall be printed on the device.

The identification is done in a total of 4 groups, where the maximum of 4 UL, is not exceeded (see Table P.1).

Table P.1 - UL ranges

Current draw of device (I)	Identification
I ≤ 1.5 mA	1 UL
1.5 mA < I ≤ 3.0 mA	2 UL
3.0 mA < I ≤ 4.5 mA	3 UL
4.5 mA < I ≤ 6.0 mA	4 UL

P.2.1.6 Switch-on Process

Conditions for the activation of the M-Bus voltage from 0 V ≤ U_{Bus} < 12 V until reaching the allowed mark state voltage:

- Strictly increasing
- Minimum slew rate : 168 V/s

NOTE: The startup delay of 3 seconds is measured from the time when the M-Bus voltage at slave terminals reaches the minimum mark voltage level of 21 V.

P.2.1.7 Upper Limit for Voltage Variation

The voltage variation between mark and space state shall not exceed the following range:

$12\ V \leq U_{delta,\ mark\text{-}space} \leq 15\ V$, where upon $U_{M\text{-}Bus,\ slave}$ shall always be ≥ 12 V

where

- $U_{delta,\ mark\text{-}space}$: Voltage variation between mark and space state of the M-Bus voltage
- $U_{M\text{-}Bus,\ slave}$: M-Bus voltage at the slave terminals for mark and space state.

NOTE: The dimensioning of the M-Bus cabling should ensure that in space state ≥ 12 V are always guaranteed at all slave terminals.

The maximum allowable voltage variation between mark and space state is derived from the requirement of [EN13757-2:2018], 4.2.2.3.

The maximum usable voltage variation between mark and space state for a specific M-Bus mark voltage level is depicted in Figure P.1.

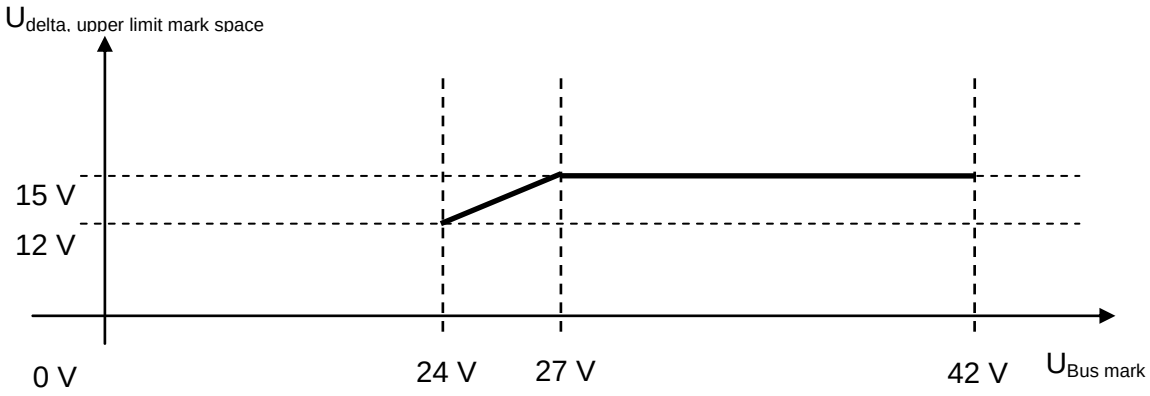

Figure P.1 - Voltage variation

NOTE: $U_{Bus\ mark}$ is the voltage level at M-Bus slave terminals. $U_{Bus\ mark}$ should consider the max allowable voltage drop U_r (for explanation see [EN13757-2:2018], 4.3.1.2).

P.2.1.8 Break Detection

All meters shall implement the break detection functionality (see [EN 13757-2:2018], 4.3.3.8 and 5.6).

P.2.1.9 Logical Slave Disconnect

[EN 13757-2] specifies that slaves shall permanently maintain a (logical) connection to the M-Bus. This also applies for OMS unless otherwise declared by the manufacturer.

The manufacturer shall declare the communication capabilities of the device for maintaining a permanent connection (e.g. battery budget for M-Bus communication and metrological functionality) and – if a protection mechanism e.g. according to P.3.2.3 is implemented – shall define the communication depot and regeneration time in the [MANDEC].

P.2.2 Link layer

P.2.2.1 Baud rates

Master and slave devices shall support 300 Baud and 2400 Baud.

Master or slave devices may support 9600 Baud, 19200 Baud and 38400 Baud.

Slave devices shall support automatic baud rate detection for all supported baud rates.

If a device supports baud rates of 9600 Baud, 19200 Baud or 38400 Baud, it shall also support the lower baud rates (see Table P.2).

Table P.2 - Required baud rate support

Maximum supported baud rate of the device	Required baud rate support				
	300 Baud	2400 Baud	9600 Baud	19200 Baud	38400 Baud
2400 Baud	X	X			
9600 Baud	X	X	X		
19200 Baud	X	X	X	X	
38400 Baud	X	X	X	X	X

Other baud rates may be supported additionally.

P.2.2.2 Change of Primary and Secondary Address

The change of the primary address shall be possible. The change of the primary address of a device shall be done using DIF = 01h and VIF = 7Ah.Other data points shall not be used. The change of the primary address shall be possible using primary as well as secondary addressing.

A change of the secondary address is not permitted. Excluded from this rule are adapters. An adapter's secondary address may be changed. The address shall be changed by using DIF = 06h/08h and VIF = 79h (see P.2.4.3).

The secondary address shall be worldwide unique (according to [OMS-S2], 3.1.2.2). For wired M-Bus devices, customer and vendor may agree to an exception to this rule. This exception shall be declared in the [MANDEC].

P.2.2.3 Special Primary Addresses FEh and FFh

A message sent with an A-field FEh or FFh for broadcast shall be handled as if it is addressed to an M-Bus slave's real primary address.

NOTE: Slaves with more than one logical address (see P.2.2.4) do not apply to this rule.

NOTE: A message sent with an A-field FFh is not answered by the meter (acc. to [EN13757-2:2018], 5.7.5.

P.2.2.4 Two or More Logical M-Buses in One Hardware Environment

Some slaves are addressable with more than one primary and/or secondary address (e.g. distinguish different functional units within one physical device).

Slave search and selection

When searching for slaves or selecting a slave address, conflicts may appear for addresses of a multi-address device. The device shall react with simulating a collision; either responding with A5h or several concatenated E5h representing the number of devices that produced the collision.

Baud rate change

A baud rate change command to a multi-address device shall always change the baud rate for the physical device and not only for the logical address the baud rate change is sent to.

NOTE: This is supported by the mandatory automatic baud rate detection for devices (see P.2.2.1)

Special primary addresses FEh and FFh

When a datagram with A = FEh is received by a multi-address device, it shall respond correctly with one of its logical addresses.

NOTE: The master can identify which of the logical units has replied according to the A-field of the respond.

A datagram sent with A = FFh shall be processed by every logical M-Bus unit (see [EN13757-2:2018], 5.7.7).

FCB handling

In case the logical device supports multiple applications and/or blocks, each logical device shall trace the last selected application and/or block independently.

In case the logical device supports multi datagram messages, there shall be a separate FCB handling implemented for each logical device.

P.2.2.5 Datagram Detection

For a stable communication on an M-Bus network, devices need to be compliant with specific wait times between a received datagram and the next datagram that is sent.

There are two different scenarios:

1. Reception of a correct datagram
2. Reception of a disturbed datagram

After reception of a correct datagram the slave needs to wait at least 11 bit times and not more than 330 bit times + 50 ms until the response is transmitted (see Figure P.2).

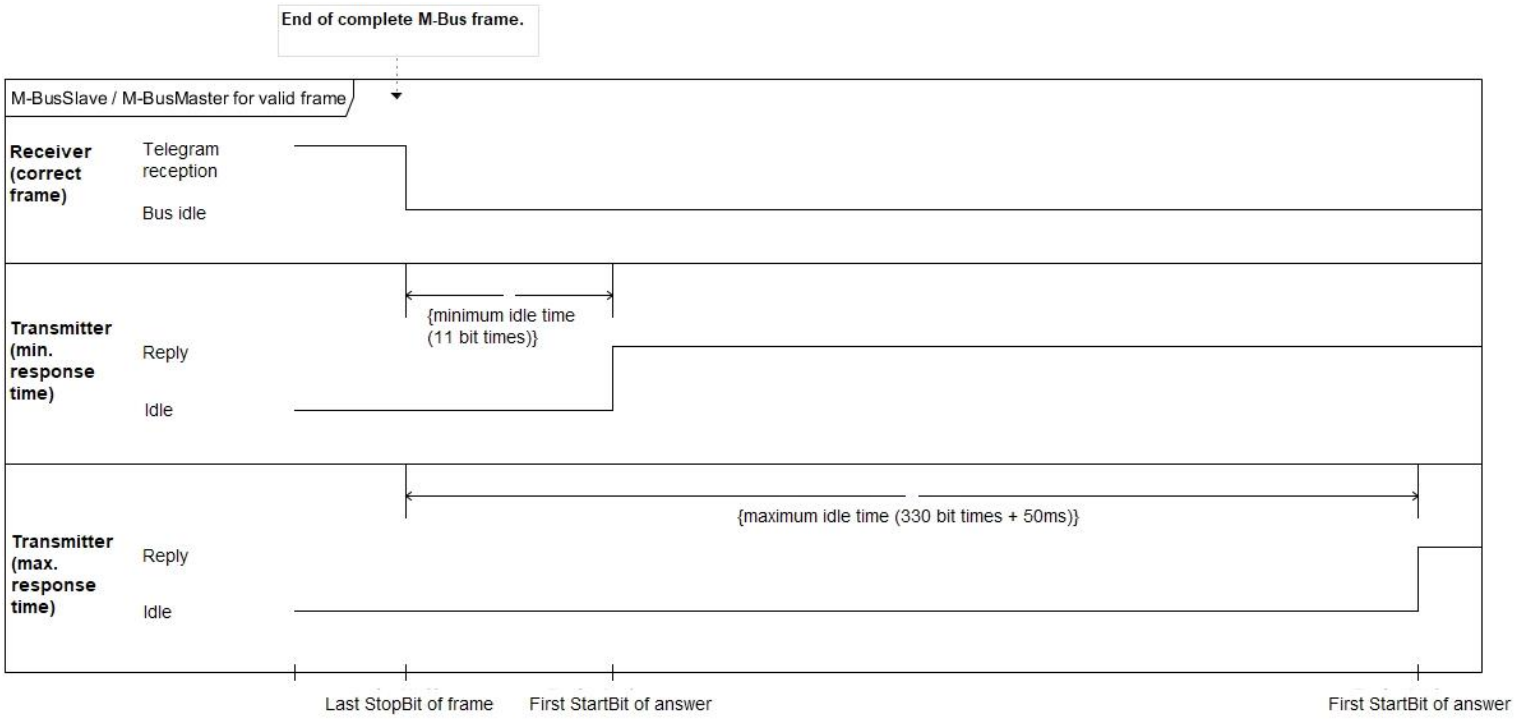

Figure P.2 - Quiescent time requirements for correct decodable datagram

If a datagram is disturbed during transmission the receiving device may detect this after +P% (see [EN13757-2:2018], Table 1) and shall detect 22 bit idle time as the end of a frame. After detection of the disturbance or the end of the frame, the next datagram may be sent (see Figure P.3).

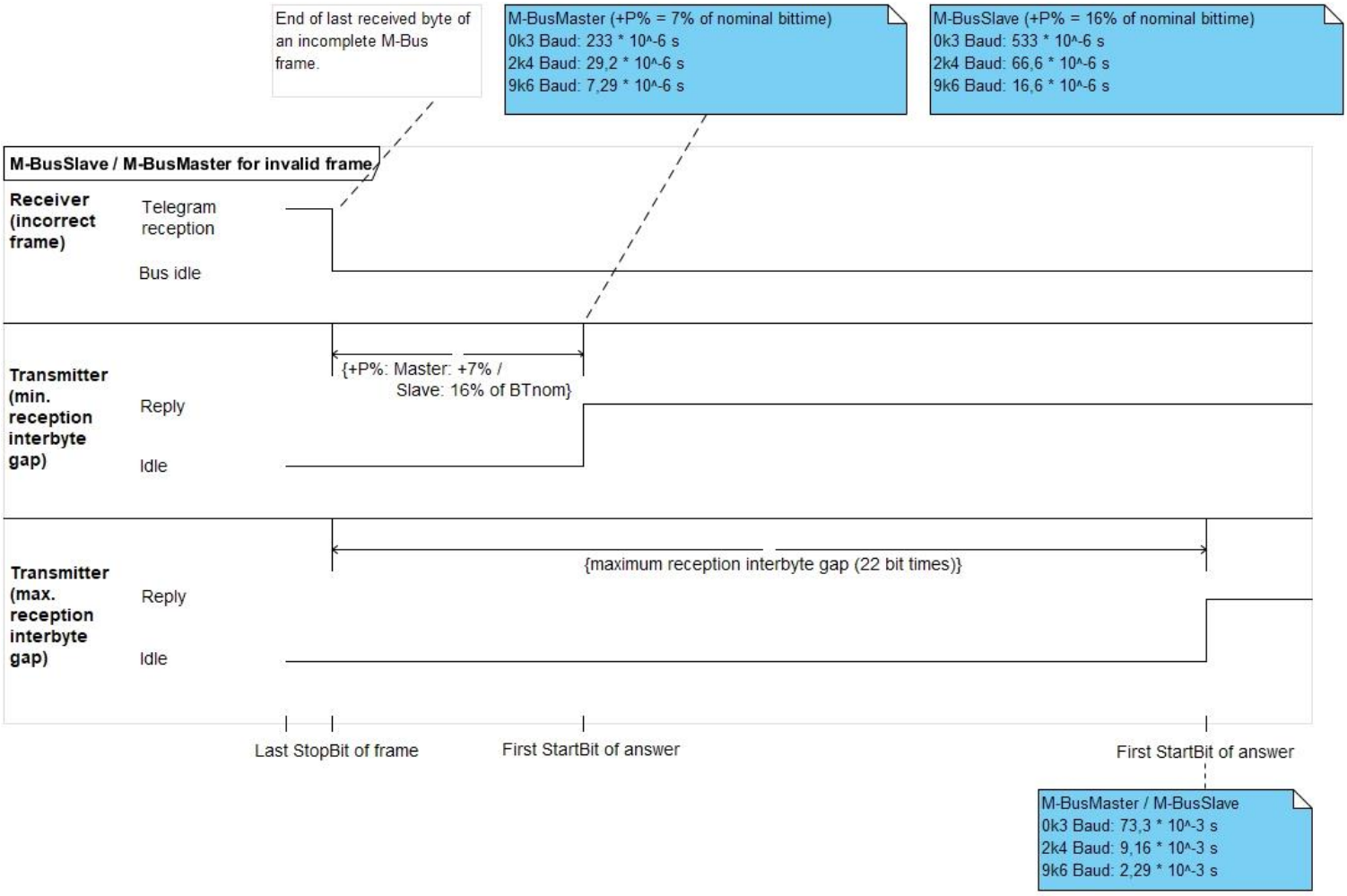

Figure P.3 - Quiescent time requirements for disturbed messages

P.2.2.6 Repetitions

P.2.2.6.1 Slave Behaviour

The slave shall be designed to respond at the first attempt. The slave shall not force repetitions systematically in order to gain time for internal purposes.

P.2.2.6.2 Master Behaviour

For mitigating communication errors (no or erroneous response in link layer, response in conflict with timing requirements) the master shall apply at least 2 repetitions.

P.2.2.7 Secondary addressing

Secondary addressing is mandatory.

P.2.3 Networking Layer / Secondary Addressing

P.2.3.1 Enhanced Selection

For slaves the enhanced selection is optional. If a slave implements enhanced selection, it shall be implemented according to [EN 13757-7:2018], 8.5.

A master shall be able to process slaves with secondary address selection as well as with enhanced selection. If a master cannot distinguish slaves using the secondary address selection, it shall use the enhanced selection.

P.2.3.2 Determination of Addresses in Adapters

Meters should be labelled with the universal meter ID (14-position identification) according to [OMS-S2], 3.2. It is recommended to label mechanical and electronic meters without wired/wireless M-Bus that can be attached to an adaptor with the universal meter ID.

If the labelling does not comply with [OMS-S2], 3.2, the following procedure shall be used to generate a unique identification (see also Figure P.4, [OMS-S2], 3.3 and [OMS-S2], Figure 7):

1. For numeric serial numbers, the following procedure shall be used:
   - If the number of characters in the serial number equals eight, the serial number shall be the identification number.
   - If the number of characters in the serial number is more than eight, the number of digits shall be reduced to the length of eight by removing the characters starting from the left (from leading numbers).
   - If the number of characters in the serial number is less than eight, the identification number shall be filled to eight places from the left with “0” (leading zeros).

2. For alphanumeric serial numbers, the following procedure shall be used:
   - The letters and special characters shall be removed from the serial number. The following steps are described in “*Numeric serial numbers*” depending on the resulting length.

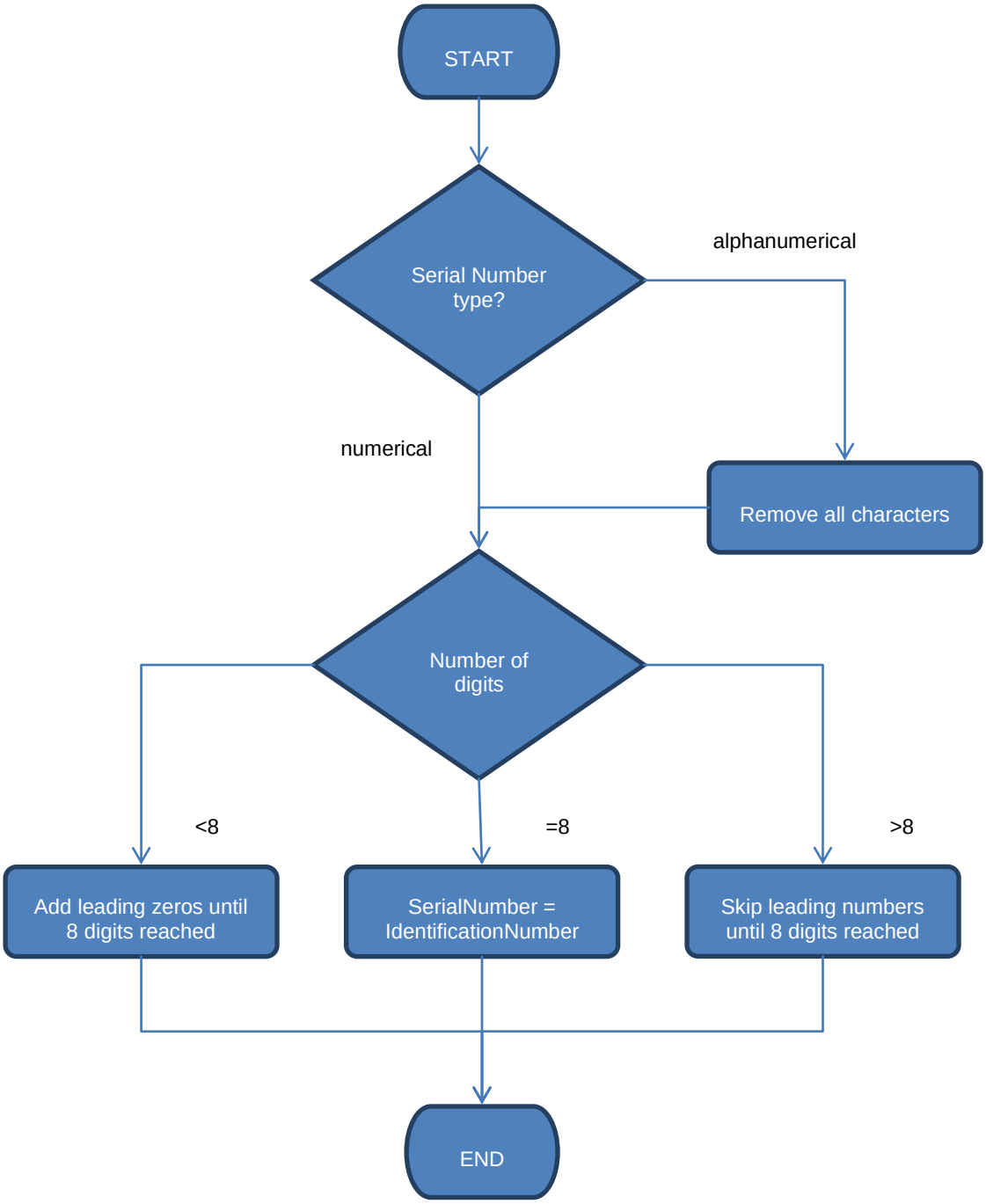

Figure P.4 - Generation of 8-digit identification number

P.2.4 Application Layer

P.2.4.1 Selection of Application Data

The selection of the application data shall only be done using the application select protocol.

P.2.4.2 Identification of a Meter Type in the Master

If a meter type cannot be uniquely identified by the header fields (manufacturer, device type, version) at least one of the fields with VIF = FDh and VIFE = 09h to 0Fh shall be present in the standard response.

P.2.4.3 Minimum Communication Capabilities for Slaves

A slave shall support the following minimum communication capabilities in addition to [EN 13757-2:2018]:

- Set the primary address with DIF = 01h, VIF = 7Ah.
- Support application reset and application select with CI = 50h or 53h.

Adapters shall support the setting of the secondary address with DIF = 0Ch, VIF = 79h. The manufacturer and version shall not be changeable in the adapter. The device type may be changeable in adapters.

NOTE: The [EN 13757-3:2018], 7.3 describes additional CI fields (54h, 55h, 66h and 68h) for special cases.

P.2.4.4 Commands for Communication If Applicable

A slave shall support setting of the due date (data type G [DIF = 42h, VIF = 6Ch]), if a calendar is present in the device.

A slave shall support setting the date and time, if a clock is present in the device. One of the data types F [DIF = 04h, VIF = 6Dh], G [DIF = 02h, VIF = 6Ch], I [DIF = 03h, VIF = 6Dh], or J [DIF = 06h, VIF = 6Dh] shall be used.

P.2.4.5 Table with CI-Fields

The CI-field 7Ah is restricted to the Wireless M-Bus (see [OMS-S2], 2.2).

P.2.4.6 New Device Type for Wired Adapters

Device type 38h is introduced for wired adapters (see [OMS-S2], Table 3).

P.3 Informative

P.3.1 Physical Layer

P.3.1.1 Cabling

P.3.1.1.1 Cable Types

The OMS recommends using a separate, shielded cable with twisted pairs for protection against EMC interferences in harsh environments.

The OMS reference cable for the M-Bus is defined as:

> J-Y(St)Y 2 x 2 x 0,8 mm ([EN 50441:2012] Cables for indoor residential telecommunication installations)

This cable type has the following properties:

- N x 2 x 0,8 mm diameter copper (0,5 mm^2 cross-section), resistance max. 75 Ohm/km per wire loop, with N = number of pairs of wires, N=1 is enough)
- twisted copper pairs
- shielding
- operating capacity at 800 Hz max. 100 nF/km
- attenuation at 800 Hz max. 1,1 dB/km

Other cables with comparable characteristics can be used. All following explanations and calculations in this document refer to the OMS reference cable type.

P.3.1.1.2 Topology

There are some basic physical configurations used for the cable connections between the M-Bus master and the slaves. These topologies are star, line and tree wiring as shown below in Figure P.5. In real installations, a combination of these topologies will be used.

A ring structure is not allowed for M-Bus systems. A termination resistor is also not allowed.

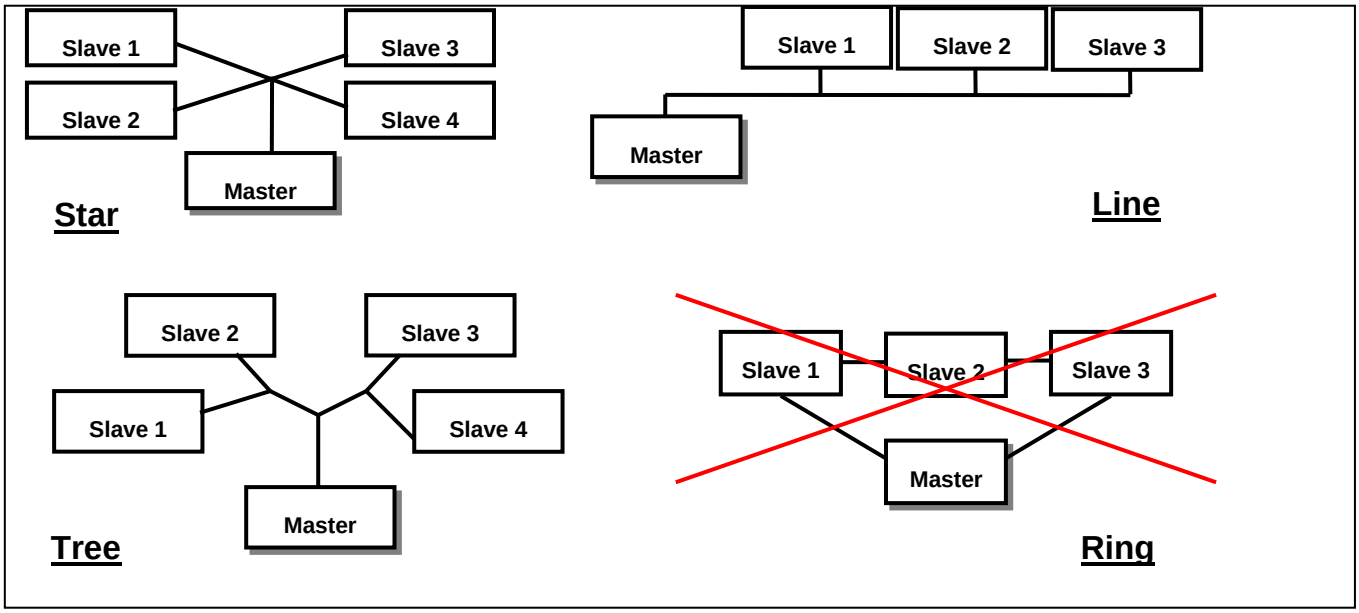

Figure P.5 - Topology variants

P.3.1.1.3 Minimum Slave M-Bus Voltage

According to [EN 13757-2:2018] the M-Bus voltage at M-Bus slave terminals shall be at least 21 V for mark and 12 V for the space state of the M-Bus voltage.

The slave requirement for a minimum allowable mark state voltage at M-Bus slave terminals is 21 V (see [EN13757-2:2018], 4.2.1).

The M-Bus voltage may fall below the typical mark state voltage of 24 V (at M-Bus slave terminals) in following cases:

- another M-Bus slave responds
- there is a data collision of two or more M-Bus slaves
- at least one M-Bus slave has a fault (for current limitation requirements in case of M-Bus slave faults see [EN13757-2:2018], 4.2.2.6)

The following diagram (Figure P.6) summarises the requirements from [EN13757-2:2018] concerning the M-Bus voltage for master and slave.

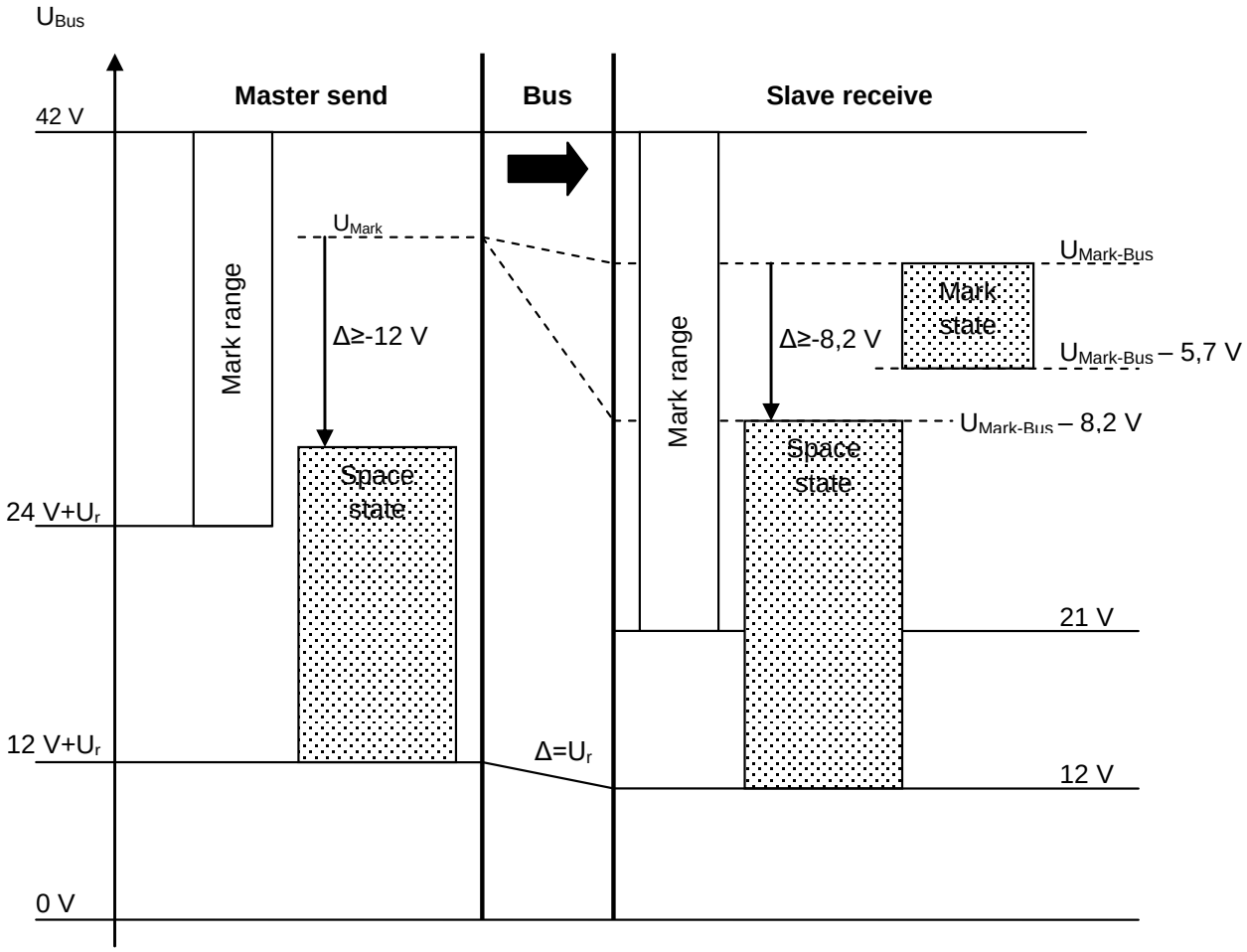

Figure P.6 - M-Bus voltage

$U_{r,\,max}$ = (max. usable bus current)*(max. bus resistance) +
(max. usable bus current)*(max. master source impedance)
> 0; with $U_{Space\text{-}Bus@MBusSlave} \geq 12$ V

The following chapters define the voltage requirements according to [EN13757-2:2018].

Electrical requirements, master

- [EN13757-2:2018], 4.3.3.1

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

- [EN13757-2:2018], 4.3.3.2

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

- [EN13757-2:2018], 4.3.1.2 Max. allowable voltage drop (U_r)

  The maximum 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 useable bus current for a given combination of segment resistance and master.

Electrical requirements, slave:

- [EN13757-2:2018], 4.2.1 master to slave bus voltages

  "…

  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}."

- [EN13757-2:2018], 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.

The following diagram (Figure P.7) represents the requirements from [EN13757-2:2018] for state recognition and collision detection for the M-Bus slave to M-Bus master communication.

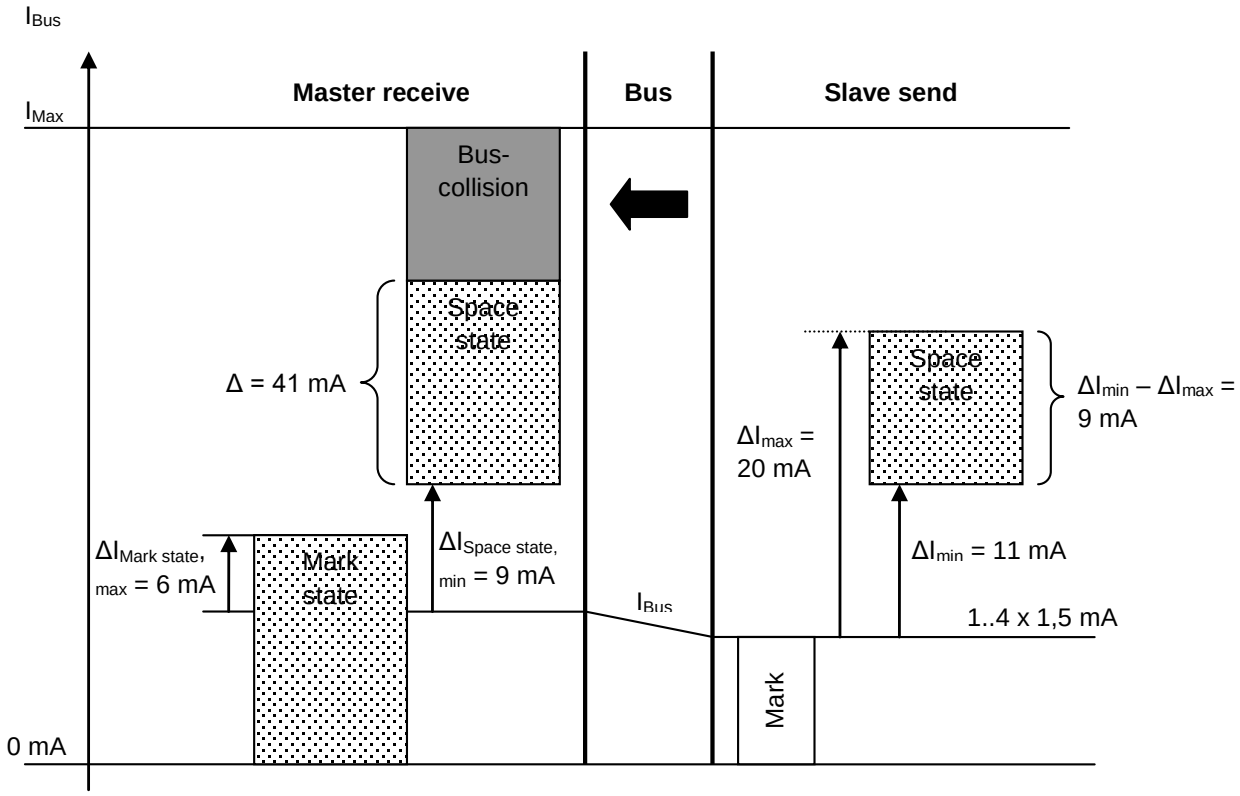

Figure P.7 - M-Bus states

$\Delta I_{Mark\ state,\ max}$: maximum allowable variation of the mark state current at the M-Bus master terminals to remain detecting mark state current.

$\Delta I_{Space\ state,\ min}$: Threshold where the master detects space state of an M-Bus slave response.

I_{Bus}: Master receive: Total of all slave currents; Slave send: Current of one slave

The following chapters define the voltage requirements according to EN13757-2:2018.

- [EN13757-2:2018], 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:

  $I_{Space} = I_{Mark} + (11 ... 20)$ mA."

- [EN13757-2:2018], 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."

- [EN13757-2:2018], 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."

P.3.1.1.4 Transmission of Remaining Energy in Battery for Communication

The VIF/VIFE for battery lifetime are defined in [EN13757-3:2018], Table 12 and Table 13:

- FDh 74h
- FDh FDh 02h

The number of remaining days/months should be continuously calculated depending on (or a combination of):

- reading frequency
- number of total readouts
- bus traffic
- measurement cycle frequency
- etc.

Applicable implementation:

- Devices with Non-Replaceable Battery:

  Battery-driven devices should transmit the remaining lifetime with every datagram.

  In case the number of days / remaining readouts decreased until the value zero is reached, the value should remain zero. Only positive values including zero are allowed.

  In case the remaining lifetime is less than 15 months, the device should set ‘power low’ in the status byte (see [OMS-S2], 7.2.3).

- Devices with Replaceable Battery:

  See ‘Devices with Non-Replaceable Battery’.

- External powered devices without limitations in lifetime and/or readout:

  Such devices are not required to transmit the remaining lifetime or requests. The ‘power low’ in the status byte is never set.

  Devices with mains power loss set ‘power low’ in the status byte upon detecting mains power loss. Upon recovery of mains power the ‘power low’ in the status byte is reset.

  Devices with an empty backup battery and/or regained external power signal this discharge state by ‘power low’ in the status byte.

P.3.2 Link Layer

P.3.2.1 Baud Rates

The following recommendations apply (see also P.3.1.1.2):

- use 300 Baud for “poor” line conditions and “long” distances.
- use 2400 Baud for standard applications and medium distances.
- use 9600 Baud or higher for “very good” line conditions and “short” distances.

NOTE: In order to have a good performance during the Slave search it is recommended to use as few baud rates as possible in the M-Bus network.

P.3.2.2 Functionality of SND-NKE

The link layer command SND-NKE has an effect on the FCB (see [EN 13757-3:2018], 5.7.7) and deselects a secondary selected slave if the SND-NKE datagram is applied with A-field FDh.

SND-NKE does not trigger any other data or state changes in the slave like change of selected application or block.

P.3.2.3 Preserving Communication Budget

The following is an example how to implement a protection mechanism for the communication:

The basic principle consists of a communication depot. Its capacity defines the amount of bytes to read without any limitations. This communication depot is constantly refilled with the communication budget.

In case the requested bytes exceed the communication budget permanently the communication depot is emptied. When the communication depot is exhausted the device is henceforth only listening.

The communication depot is constantly refilled with the number of bytes defined by the communication budget. When the threshold to support a readout of at least three datagrams is reached, the communication is released again. The duration from pausing communication until its release is the regeneration time.

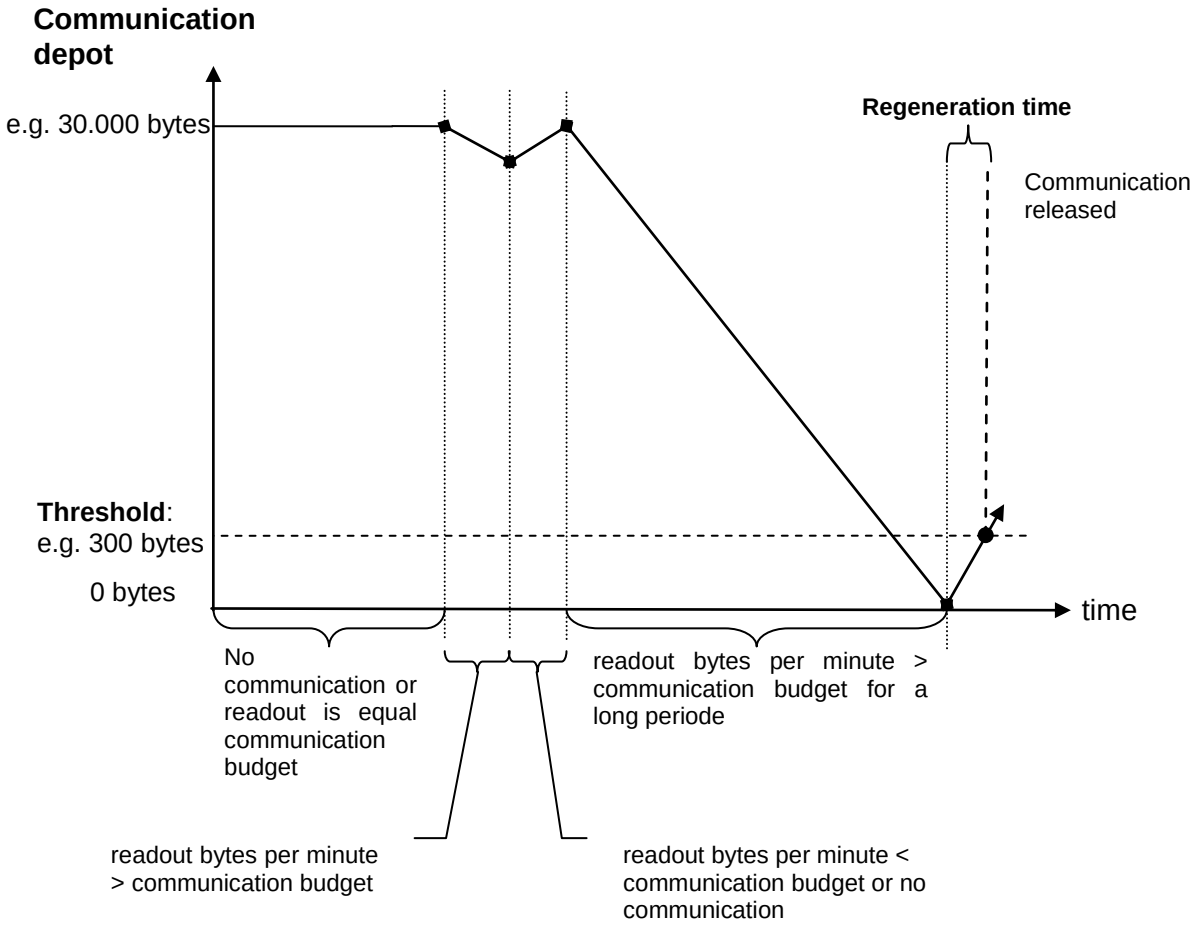

Figure P.8 - Communication depot

NOTE: The device should send at least an application error 09h according to [EN13757-3:2018], 10.3 before the communication is stopped due to an empty communication depot.

NOTE: For a selection of the above given parameters, the following minimum values should be applied:

Table P.3 - Example for minimum requirements

Minimum requirements for communication budget	Value
Communication budget	50 bytes/minute
Regeneration time	Maximum permitted value: 1080 seconds
Communication depot	30.000 bytes

P.3.3 Networking Layer / Secondary Addressing

P.3.3.1 Repetitions

P.3.3.1.1 Secondary Address Search (Slave Select)

The repetition of a secondary selection is not obligatory.

The slave select should be repeated twice in the following conditions:

- if there is no valid response at a search with secondary address with the defined timing conditions;
- if there are still collisions at a maximum restricted search area.

P.3.3.1.2 Deselection

SND-NKE to primary address 253 or 254:

- A SND-NKE to address 254 does not change the status of the slave selection.
- Having received an ACK (E5h) as response to a SND-NKE to address 253 no repetition is required.
- Having received no valid response to a SND-NKE to address 253 or 254 (no or erroneous response in link layer, response in conflict with timing requirements) at least 2 repetitions should be sent.

SND-NKE to primary address 255:

- A SND-NKE to address 255 does not change the status of the slave selection.
- The slave should apply the first received SND-NKE and resets the FCB.
- The master may apply SND-NKE several times.

By selection of a new slave:

- Having received an ACK (E5h) as response there should be no repetition.
- Having received no valid response to a slave select (no or erroneous response in link layer, response in conflict with timing requirements) at least 2 repetitions should be sent.
- A selected slave should deselect at the first selection command for another secondary address.

  NOTE: If an explicit deselection confirmation is required the following procedure can be applied:
  - Deselection of the selected slave with SND-NKE.
  - The slave confirms the deselection with ACK.
  - Selection of the required slave with the selection command.

  This procedure requires a communication overhead compared to the immediate selection command, but ensures that the previously selected slaves are really deselected. Under “poor” M-Bus line conditions it is possible that a selected slave does not receive the slave selection command of a new slave which leads to at least two selected slaves on the bus.