BS EN 13757-5:2015

BSI Standards Publication

Communication systems for meters

Part 5: Wireless M-Bus relaying

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National foreword

This British Standard is the UK implementation of EN 13757-5:2015. It supersedes BS EN 13757-5:2008 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PEL/894, Remote Meter Reading.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Kommunikationssysteme für Zähler - Teil 5: Weitervermittlung

This European Standard was approved by CEN on 22 August 2015.

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European foreword

This document (EN 13757-5:2015) has been prepared by Technical Committee CEN/TC 294 “Communication systems for meters”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2016, and conflicting national standards shall be withdrawn at the latest by May 2016.

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

This document supersedes EN 13757-5:2008.

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

EN 13757 comprises the following parts:

— *Part 1: Data exchange*

— *Part 2: Physical and link layer*

— *Part 3: Dedicated application layer*

— *Part 4: Wireless meter readout (Radio meter reading for operation in SRD bands)*

— *Part 5: Wireless M-Bus relaying*

— *Part 6: Local Bus*

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

1 Scope

This European Standard specifies the protocols to use when performing relaying in wireless meter readout networks. This European Standard is an extension to wireless meter readout specified in EN 13757-4. It supports the routing of modes P and Q, and simple single-hop repeating of modes S, T, C, F and N.

The main use of this European Standard is to support simple retransmission as well as routed wireless networks for the readout of meters.

NOTE Electricity meters are not covered by this standard, as the standardization of remote readout of electricity meters is a task for IEC/CENELEC.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 13757-1:2014, *Communication systems for meters — Part 1: Data exchange*

EN 13757-3:2013, *Communication systems for meters and remote reading of meters — Part 3: Dedicated application layer*

EN 13757-4:2013, *Communication systems for meters and remote reading of meters — Part 4: Wireless meter readout (Radio meter reading for operation in SRD bands)*

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

EN 60870-5-2:1993, *Telecontrol equipment and systems — Part 5: Transmission protocols — Section 2: Link transmission procedures (IEC 60870-5-2:1992)*

EN 62054-21:2004, *Electricity metering (a.c.) — Tariff and load control — Part 21: Particular requirements for time switches (EN 62054-21:2002)*

RFC 1662 July 1994, *HDLC-like Framing, Appendix C. Fast Frame Check Sequence (FCS) Implementation*

ETSI EN 300 220-1:2012, *Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Radio equipment to be used in the 25 MHz to 1 000 MHz frequency range with power levels ranging up to 500 mW; Part 1: Technical characteristics and test methods*

CEPT/ERC/REC 70-03, *Relating to the use of short range devices (SRD)*

3 Terms and definitions

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

3.1
Bidirectional Single Hop Repeater
BSHR
repeater retransmitting original frames in upstream as well as downstream direction

Note 1 to entry: The 'H' bit in the Extended Link Layer shows whether or not frames are original or repeated.

3.2
block
sub-element of a frame

Note 1 to entry: For an EN 60870-5-1 based protocol; this will be up to 16 bytes of user data completed by a CRC check.

3.3
downlink
transmission in downstream direction

3.4
downstream
transmission of data in the direction from the Data Collecting Unit to the Meter

3.5
end node
Meter or Data Collecting Unit

Note 1 to entry: The Data Collecting Unit is named Other Device in EN 13757-4.

3.6
frame
set of data encapsulated by a header and optionally a trailer

Note 1 to entry: For an EN 60870-5-1 based protocol this will be a start character followed by up to 16 blocks of data.

3.7
gateway
intermediate node in a data communications network, connected to two or more logical networks, where the protocols or modes used on the logical networks are different

3.8
hop
transfer of a set of data from one node to an adjacent node, as one of the steps in the transfer of data between end nodes

3.9
intermediate node
node in a network sitting in-between a Data Collecting Unit and a Meter

3.10
meter assignment
exclusively pairing a Meter to a repeater

Note 1 to entry: This is performed by Network Control. This allows access and downstream communication to the meter.

3.11
meter registration
registration of a meter in one or several repeaters

Note 1 to entry: This allows the repeater to repeat the transmissions from the Meter upstream.

3.12
Network control
NC
logical unit to control and supervise repeaters in the network

Note 1 to entry: Network Control may be located in a Data Collecting Unit, in a repeater or in a dedicated device outside the network.

3.13
node
unit in a network that is able to send and receive data

3.14
Other Device
Data Collecting Unit

Note 1 to entry: This is the term used in EN 13757-4.

3.15
primary station
network node that controls all of the data exchange in a simple network with one central node, unbalanced data transfer and multiple remote nodes

Note 1 to entry: All data transfer will (normally) be controlled by the primary station. A Data Collecting Unit will be a primary station.

3.16
radio scan list
list of all Meters having sent a valid frame

Note 1 to entry: Entries in this list will be removed after a certain time (time out).

3.17
relaying
forwarding of information from one logical network to another

3.18
repeat meter list
RML
list of end nodes registered for repetition

Note 1 to entry: The list is allocated to (and downloaded into) a repeater by Network Control. The list is generated from meter assignment and meter registration.

3.19
repeater
intermediate node in a data communications network, retransmitting data without modifying address information

3.20
router
intermediate node in a data communications network, connected to two or more logical networks with identical protocols and modes

3.21
secondary station
node in a hierarchical network, that is able to receive commands and requests from a central node, the primary station, and to send a response back to the central node

Note 1 to entry: A Meter will be a secondary station.

3.22
Uni-directional single hop repeater
USHR
repeater retransmitting original frames in upstream direction only

Note 1 to entry: The 'H' bit in the Extended Link Layer shows whether or not frames are original or repeated.

3.23
uplink
transmission in upstream direction

3.24
upstream
transmission of data in the direction from the Meter to the Data Collecting Unit

4 Symbols

The following symbols are used for timing parameters on drawings in Annex A.

t_{DRFS}	Time delay repeater, fixed, start of message reference
t_{DRFE}	Time delay repeater, fixed, end of message reference
$t_{DRSlotN}$	Time delay repeater, where N may be 1 to 7
t_{DRR}	Time delay repeater, randomized
t_{IA}	Time delay Installation Announcement
t_{RO}	Time for response from Other Device (default, fast)
t_{RO_slow}	Time for response from Other Device(slow)
t_{RR}	Time for response from repeater (default, fast)
t_{RR_slow}	Time for response from repeater (slow)
t_{TxD}	Time delay for transmission in Frequent Access Cycle (FAC)

5 Introduction

5.1 General

This clause is an explanatory clause, and the specific requirements are to be found in the latter clauses of this European Standard.

5.2 Use of retransmission

The availability of low cost radio modules has made it feasible to use radio communication for the readout of meter data. Many meters are battery operated and have a very strict power budget and regulatory requirements are imposed as well. This limits the transmitting power levels and thereby the useful distance between transmitters and receivers. The use of reinforced concrete, conductive surface coatings and placement of meters below ground level like in pits and in the basement of the buildings aggravates the problem of directly communicating between a data collecting unit and a meter. This limits the useful size of radio networks unless forwarding is used. By letting some of the nodes forward, the effective size of the network can be increased. This makes radio based networks a more cost effective solution.

A forwarding concept will still have a number of constraints. The cost of adding this capability to the meters has to be low, since meters are cost sensitive high volume products. The limited energy and computing power available in the individual nodes mandates a limited complexity of the software handling the communications protocol and the forwarding.

Operating and installation costs are important factors when planning for meter networks. The reconfiguration of the network when adding, replacing or removing meters may be automated to limit the operating cost.

The overhead due to forwarding of data transmitted is required to be low to keep the transmission duty cycle within the limitations imposed by the authorities.

The fact that meters are cost sensitive devices makes it advantageous to allow for simple single-hop retransmission (repeating) as well. This transmission works mainly at the Physical Layer level. Such repeaters have a limited functionality but cover the needs for low cost meters. The architecture of such repeaters is described in the subclause below and is specified in detail in Clause 9.

5.3 Repeating

If a direct transmission between a Meter and an Other Device is not possible a repeater may be used in between. Such a repeater shall be able to work without complex installation procedures and without routing capability. The single hop repeater shall support one-way or two-way communication.

NOTE A repeater according to this European Standard is only able to forward the message for a single hop.

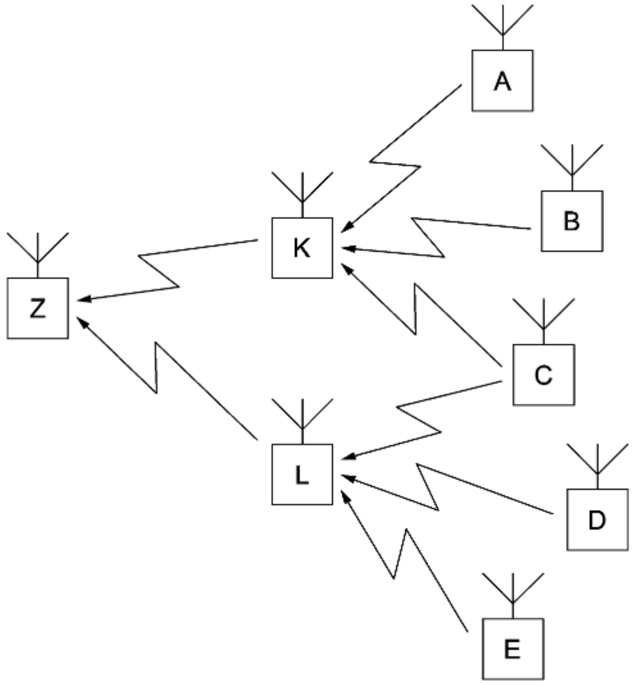
— Unidirectional Single Hop Repeater (USHR) only repeating messages from the Meter upstream to the Other Device.

— Bidirectional Single Hop Repeater (BSHR) repeating messages in both directions, i.e. from the Meter upstream to the Other Device and from the Other Device downstream to the addressed Meter.

A repeater may, at the same time, operate as an USHR for some meters and as a BSHR for other meters.

The network architecture is shown on Figure 1. The Meters A, B, C, D, and E, are not always able to reach the Other Device Z directly. Two repeaters, K and L, are inserted to handle this. Meters A, B, C are able to reach repeater K that will forward the frames to the Other Device Z. Meters C, D and E are able to reach repeater L that will forward their frames to the Other Device Z. Repeater K may as well be able to receive the data from repeater L but it will not repeat the frames once more, as a 'repeated flag' is already set in the frame.

Meter C is able to reach both repeaters. This can generate duplication and collisions. A randomized timing in the individual repeaters ensures that the frame from a meter will not collide frequently if it is repeated by multiple unidirectional single hop repeaters.



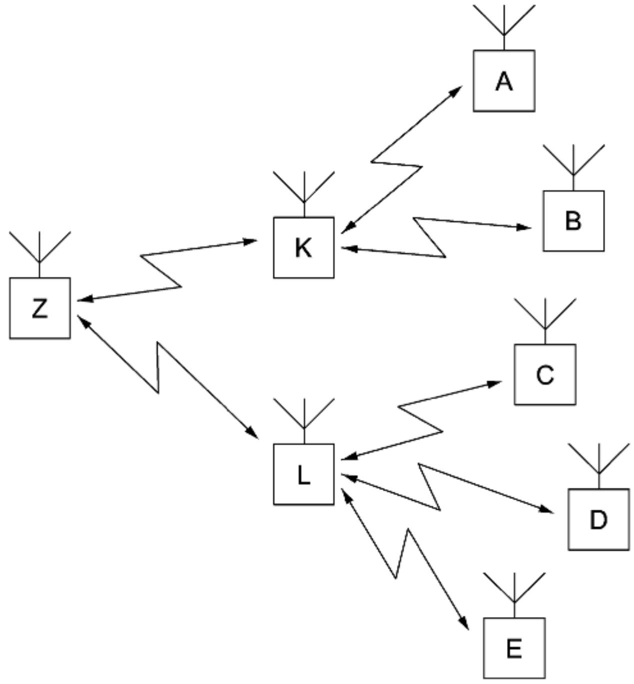
Key

A – E meters

K – L repeater

Z Other Device

Figure 1 — Unidirectional Single Hop Repeater, USHR



Key

A – E meters

K – L repeater

Z Other Device

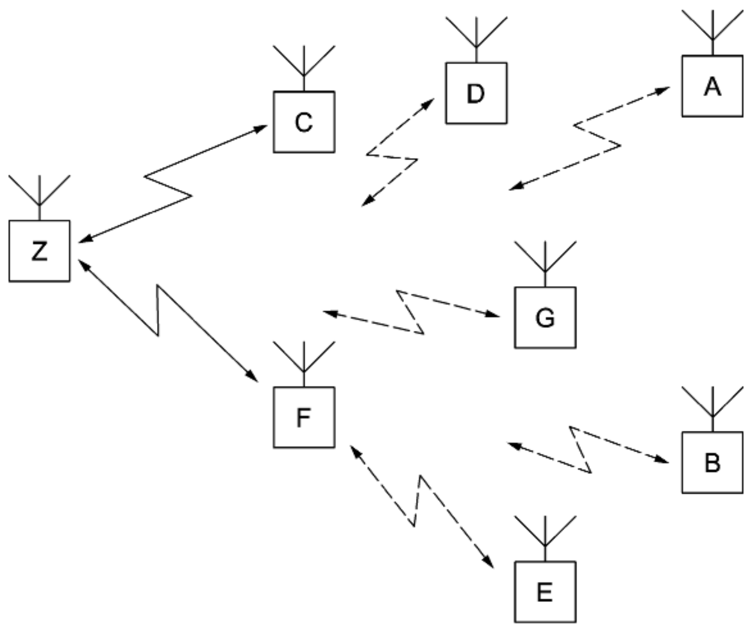
Figure 2 — Bidirectional Single Hop Repeater, BSHR

Bi-direction repetition, as shown on Figure 2, may get a little more complex once bidirectional meters and repeaters are used. The bidirectional meters may, for energy saving purpose, only enable its receiver in a narrow listening window. The setup in the repeater ensures that any response from the Other Device is transmitted in this listening window. The details of this are specified in Clause 9.

5.4 Relaying

5.4.1 Overview

A radio network may have a structure like the one shown in Figure 3 below. The Nodes A, B, C, D, E, F and G are simple meters. They all need to communicate with Node Z, the data collecting unit / the primary station. In the current setup only the Nodes C and F, are able to reach the Node Z. The other nodes cannot reach the Node Z. The useful size of this network is thereby limited to only 2 nodes, Nodes C and F.



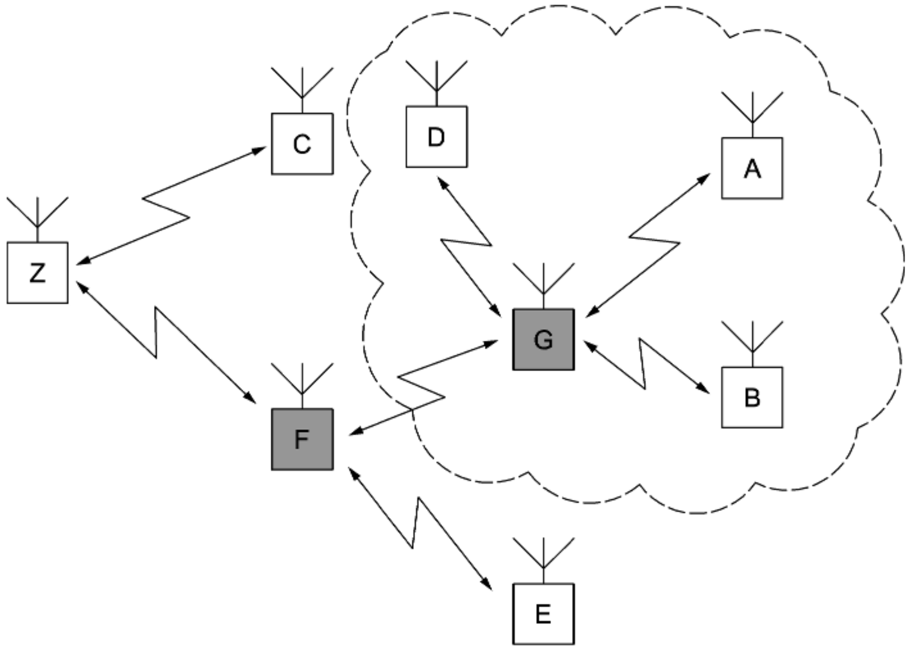
Key

A – G simple meters

Z data collecting unit/primary station

Figure 3 — Network with simple nodes, without relaying

Extending the network by adding some nodes with relaying capability will give a structure as shown on Figure 4. Nodes F and G have now been extended to include relaying capability. Communication between Nodes A, B and D and the primary station is achieved by relaying the data through Nodes G and F. Node A sends data to node G, node G relays data to node F and node F relays data to the Node Z, the data collecting unit. The size of the network can now be extended to include all of the nodes shown. The Nodes F and G may be dedicated relaying nodes or meters with extended capabilities. Transmission from one node to another is called a hop. The transmission from node A to the data collecting unit/primary station consists of three hops.



Key

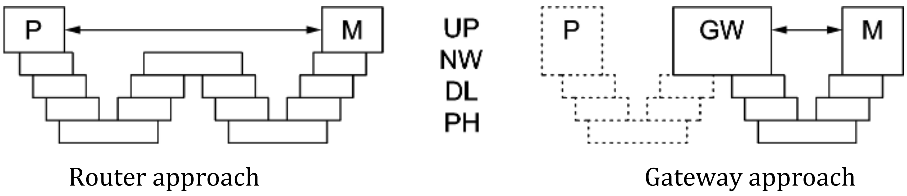
A – E simple meters

F, G nodes with relaying capability

Z data collecting unit/primary station

Figure 4 — Network with relaying nodes

Remark that the network still has a hierarchical structure at the application level, despite the relaying nodes. All end-to-end data transfer is performed between the data collecting unit and the meters. The meters do not communicate with one another at the application level nor do the relays.



Key

UP upper layers (Transport – Application)

NW Network Layer

DL Data Link layer

PH Physical layer

M meter

GW node with relaying capability (gateway)

P data collecting unit/primary station

Figure 5 — Router vs. gateway solution

The relaying can be performed in two different ways as shown in Figure 5 using either a gateway or a router approach.

In the router approach all nodes in the network are aware of the other nodes in the network and they all use the same protocol in both directions. The nodes are aware of the routing capability of certain nodes as well. Node B, as shown on Figure 4 will know that it for instance has to send data through the relaying Nodes G and F to reach the data collecting unit.

In the gateway approach only the locally reachable nodes are known. Nodes beyond the gateway are hidden. To Nodes A, B and D in Figure 4, the network is limited to the area inside the dashed line, and node E is to all subordinate units the "data collecting unit'. The gateways are organised in a hierarchy of networks as well, as shown in Figure 4, where node E is at the bottom of the hierarchy, node F is one level above it and node Z the real data collecting unit is at the top level.

The generic details of the gateway and the router approach are specified in the following sub clauses.

5.4.2 Use of routers

In a routed network the nodes all behave like peer entities at the network level. Transfer between nodes is based on pairs of addresses, the sender node address and the receiver node address. This allows for a non-hierarchical structure of the nodes in a network with parallel paths.

The fact that a pair of addresses is needed makes the routed approach incompatible with the data link layer used in EN 13757-4. There is thus a need of being able of distinguishing between native EN 13757-4 data and routed data at the data link layer. This to ensure that simple nodes do not try to decode and handle routed data by mistake.

The way of selecting the path to use when sending a package through a network can be determined in two ways. The first is the hop-by-hop method. Here the full path is set up prior to the first transmission, and it includes all the nodes to connect through. The second method use network generated paths. Here the first node sends the data to suitable neighbour router, and this router then determines the next hop for the data, based on its routing information. This latter method is the one used by the IP protocol on the Internet. The approach selected for this application is the hop-by-hop addressing method, as this is less complex to implement and requires less network traffic overhead and less intelligence in the nodes in the network.

5.4.3 Use of gateways

A simple node has only a single address field. It is only able to work in a network with a single primary station controlling the network and one or more secondary stations / meters. A simple node will when receiving data look for its own address in the address field. It will assume that all data sent to it originates from the primary station. A simple node will when responding include its own address in the header. It will assume that all data will be received by the primary station.

The gateway hides the network and network complexity from the simple nodes. To the nodes the gateway appears as the primary station. If the network shown in Figure 4 is using the gateways approach, then node G will appear as the primary station to Node A, B and D. Node E will assume that node F is the primary station, and only node C will actually connect directly to node Z, the data collecting unit. A gateway node may be a dedicated node, or a meter with extended functionality.

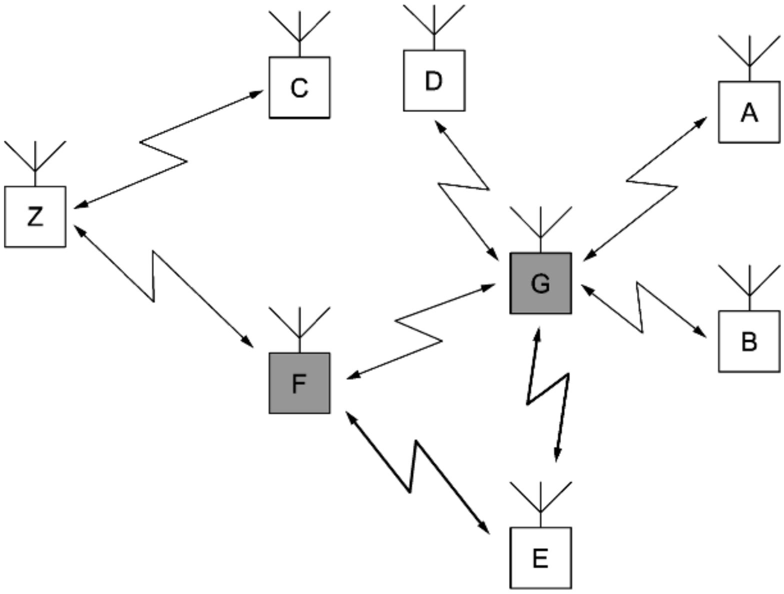
The gateway will when sending data downstream to the simple node(s) appear like the primary station. It will when receiving data sent upstream from a simple node appear like a primary station.

The gateway does not have any prior knowledge of the overall network configuration. Relaying of data will either be based on fixed rules, or on information provided in the header of the data. Both of these approaches are used in this gateway protocol.

The gateway may when data are sent upstream use the generic rule that the network is hierarchical. The gateway will when it has received data from a simple node to be sent upstream forward them further upstream. Data will then be received by another gateway or the primary station. There is no need for destination addressing of data sent upstream.

5.4.4 Data duplication

Not all data sent upstream should be forwarded, as this may cause data duplication. This can be seen on Figure 6 below.



Key

A – E simple meters

F, G nodes with relaying capability

Z data collecting unit/primary station

Figure 6 — Data duplication

Data sent by Node E can be received by gateway G as well as by gateway F. When Node E sends a set of data, it will be received by both gateways. One set of data will be sent along the path E – G – F to node Z, the data collecting unit and another set of data will be sent along the path E – F to node Z. The use of unconditional relaying will cause duplication of the data received by the data collecting unit and cause unnecessary traffic on the network as well. Methods and rules needs to be implemented to ensure that data duplication is limited.

Two issues should be handled when looking into avoidance of data duplication;

a) Whether to use enabling or disabling lists,

b) Whether to use a list of local or global nodes.

The nature of radio communication is that the actual transmitting distance may vary a lot over time. It is thus not feasible to generate a list of nodes, not allowed to relay for. Special transmitting conditions, due to for instance special metrological conditions, may make it possible to hear nodes located far away. It is as well possible, that a new operator, also following this European Standard, could set up new nodes that were not known, when the initial network was set up. Data from the new nodes is not to be performed by default, but there is no possibility of knowing the coming of these nodes in advance. These are examples of situations that cannot be handled orderly by a disabling list. An enabling list shall therefore be used.

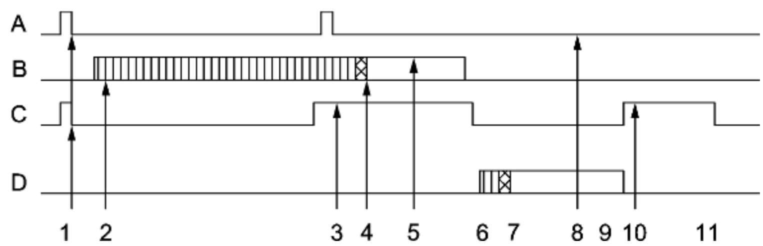
The use of a global list of nodes, would require, that nodes at the higher levels of the hierarchy contains very large lists holding the address of all subordinate units it is to receive data from. All possible intermediate nodes has as well to contain information about all their subordinate nodes. This would require a lot of data memory in the gateways, and cause a lot of network traffic when the lists are to be updated. The use of a local list has therefore been evaluated as superior, and selected. The use of a local list has the minor drawback that data sent upstream needs to contain the (local) address of the sending node, as well as the address of the originator, the meter.

The gateway will need further address information when it receives data to be sent downstream. It has to know what node(s) to forward the data to. This information, network control information, is to be available as a part of the header of the data.

Modes using gateway are no more a part of this standard.

5.4.5 Use of power strobed units

Many meters and intermediate nodes are battery operated, and have to operate from a single battery for several years. This makes it necessary to conserve power by switching off part of the circuits in the node when not in use. One such part is the radio. This is further described in Figure 7. The control program in a node may, when the node is not communicating, only switch on the receiver briefly with fixed intervals (1, 3). This listening will be disabled when the node is transmitting (8). Another node wanting to communicate with the power strobed node then sends a wake up signal (2). The power-strobed receiver will during its listening interval look for data transfer of the expected type (a wake up signal), and will switch off again if no data transfer is detected (1). The receiver shall, once wake up is detected (3), look for a synchronization pattern (4) and start to collect data (5). The receiver may, if the destination address of the information does not match that of the node switch off to conserve power. A node should, after the transmitter in the node has been active (6, 7, 9), switch on the receiver for a period (10, 11) in anticipation of a response to the transmitted message. Such behaviour will improve the processing of the data, and limit the duty cycle, as no wake up sequence is needed.



Key

A receiver 'listening' window

B 'wake up' and data signal

C receiver active

D data transmitted

Figure 7 — Power strobed receiver

The duration of the wake up sequence shall be long enough that it is detected by the node during the first listening interval to ensure an effective data transfer, i.e. be longer than the listening interval of the receiver.

To prevent unnecessary wake up of meters the wake up signal uses a different data rate than normal data transfers. On-going data transfers between nodes will not awake sleeping nodes, thus saving power.

The parameters specifying power wake up behaviour should be standardized to ensure energy efficient data transfer in the radio network.

5.4.6 Error handling

The data error rate will be higher in a radio based network than in a wired network. Some of the reasons for this are:

— The units are operating in a license free band, where a lot of other units may be operating at the same time. Such units may garble or block the transmission between a pair of nodes in the metering network.

— Noise from other sources may impair the signals.

— The radio transmission conditions may change due to changes in the environment (new building erected, container placed in front of the meters) or changes in weather conditions.

— The transmission of information from a meter to the data collecting unit may traverse multiple links. The overall transmission is only successful if all of the individual hops, forth and back, are successful.

All this makes it necessary with an efficient error handling algorithms in a radio based multi-hop networks. That is networks with routers or gateways. To alleviate the error handling, the following concepts are implemented in the protocols mode P and mode Q:

— data transmission is acknowledged for each hop;

— there is a fast acknowledge at the link layer;

— a negative acknowledge is returned if the message that should have been acknowledged, is garbled and the sender can be identified;

— a standardized retry algorithm is used.

If the retry algorithm fails, then the originating node is informed about the failure and about the hop where the failure occurred. This information is provided to higher layer protocols that may attempt to reroute the traffic through other nodes in the network. The protocols for such rerouting are outside the scope of this European Standard.

5.4.7 Time synchronization

New regulations in the energy market [COM (2003) 739 Final] demand improved energy efficiency. This requires reporting of actual time of use and thereby precise time information from the meters. Standards for energy meters, like EN 62054-21 already quantify these requirements. This imposes capabilities of precision timing in the meters, and thereby for a communications system that allows for a precision time synchronization through the network.

This need is to some extent in conflict with the use of power strobed meters and routers as shown in Figure 8.

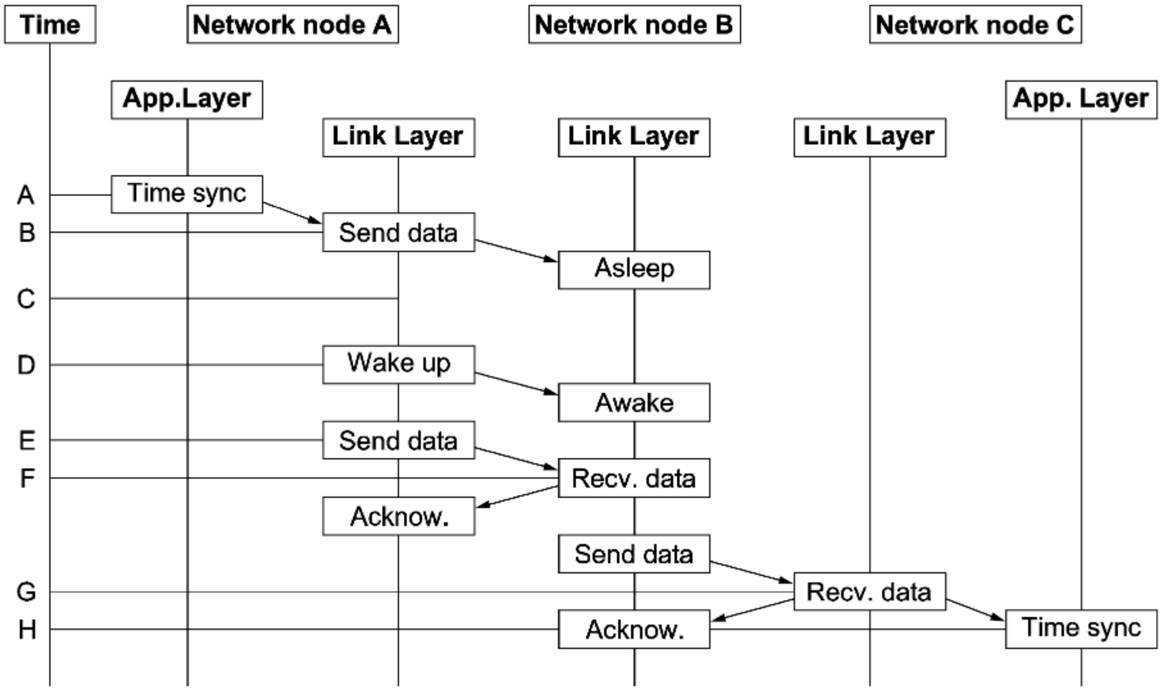


Figure 8 — Time synch propagation

The scenario is that a network Node A distributes a time synchronization signal to some other nodes in the network, Nodes B, C. One of the receiving Nodes B is asleep and will need a wake up signal before data can be transferred to it.

The management application in node A retrieves the time information at t_A. The information is processed by the lower protocol layers in the node, and sent to the network at t_B. The information is not detected by the receiving node that is asleep. This will at t_C cause a timeout condition in the sending Node A, as no acknowledge signal is received. The time-out condition will cause the link layer in node A to send a 'wake up' signal at t_D, followed by a retransmission of the packet at t_E. The receiving Node, B, is now awake and will receive the data at t_F, acknowledge the packet, and send the packet on to Node C. Node C receives the data at t_G, and passes the information on to the application layer at t_H.

The synchronization time in the application data is t_{BA}, whereas the actual time is t_H. This time difference t_H - t_A will be in the (multiple) seconds range if one or more of the intermediate nodes were asleep prior to the transfer. This is not acceptable according the requirements for modern meters in EN 62054-21.

It is necessary to have a transmission protocol that ensures that precise timing information can be transferred. Such a protocol takes into account the delay introduced during the end to end transmission. This information is updated for each hop in the transmission. This processing of the data takes place at the link layer of the nodes. Experience from other precision timing protocols like IEEE 1588-2002 shows that this requires a special handling at the lower protocol layers. A special set of lower layer protocols will be specified for this purpose. The protocol shall contain a synchronization time t_A as well as delay information t_H - t_{BA}. The synchronization time is a part of the application data. The delay information is a part of the link layer information. The delay information is updated for each hop / retransmission of the data. This protocol may be used, if requirement for precision timing exists.

NOTE The use of this protocol will require that an Application Layer gateway is used if interfacing to meters using an EN 13757-4 interface.

5.5 Protocol possibilities

Based on the general needs expressed in this clause, three different protocols for relaying in a radio network are defined. They have the following general characteristics;

— A router based protocol. This protocol, named Mode P, extends the addressing to a dual address /balanced protocol, as used by all modern Data Link Layer protocols. This is done using the EN 60870-5-1 physical layer and EN 60870-5-2 link layer. Nodes using the mode P protocol cannot communicate directly with R2 nodes but the nodes can coexists in the same frequency band. The P and the R2 protocols are by structure very similar and dual-mode nodes supporting mode R2 as well as mode P may be foreseen. This is the protocol to use when one wants to use a true routed network with full addressing, but at the same time wants to keep the general structure of the R2 protocol.

— A contemporary protocol supporting precision timing. This protocol, named mode Q, is intended where one has not the need of following the EN 60870-5 series of standards. These EN 60870-5 series of standards were developed around 15 years ago and do not fulfil all the needs of a modern protocol. Mode Q takes into account; the possibility of energy saving using power strobing of the nodes, the needs for transfer of precision timing information and the possibility of using NRZ coding based on digital signal processors. The protocol is applicable as the transport service for a modern object oriented high level Application Layer service like the DLMS protocol specified in EN 13757-1.

— Single hop repeating protocol. A physical and link layer protocol. It is applicable to nodes using the Modes R, S, T, C, N and F as specified in EN 13757-4.

6 Mode P, protocol using routers

6.1 General

This protocol is applicable to communication between nodes with routing capability. The protocol shall use Mode P at the Physical Layer and the Data Link Layer to ensure that nodes without routing capability do not try to handle such messages.

The protocol is optimized for battery operated units with power strobed radio unit.

6.2 Physical Layer protocol

6.2.1 General

All the parameters shall, at the minimum, conform to ETSI EN 300 220, even if some applications may require extended temperature or voltage range. The channel and frequency band shall be as specified in Table 1.

Table 1 — Mode P, General

Characteristic	Min	Typ	Max	Unit
Frequency band [a]	868,0		868,6	MHz
Channel spacing		60		kHz
Transmitter duty cycle [b]			1	%
NOTE The characteristics are, for the SRD band, identical to the characteristics for the S and R2 modes in EN 13757-4.				
a The standard is optimized for the 868-870MHz band, but with local radio approval, it may allow for operation in other frequency bands. b Duty cycle shall be as defined by ETSI EN 300 220-1 in the SRD bands. It may with local radio approval allow for other duty cycles in other frequency bands.				

6.2.2 Transmitter

The parameters for the transmitters shall be as specified in Table 2.

Table 2 — Mode P, Transmitter

Characteristic	Sym	Min	Typ	Max	Unit	Remark
Centre frequency, [a] (Other Device)			868,330		MHz	
Centre frequency [a] (meter)			868,030 + n × 0,06 [h]		MHz	
Frequency tolerance (meter / Other Device)			0	±17	kHz	~20ppm
FSK Deviation		±4,8	±6	±7,2	kHz	
Chip rate Wake up [b]			3,12		kcps	
Chip rate tolerance, Wake up			0	±2,5	%	
Wake up signal duration	t_{WD}	5200		6000	µs	
Chip rate Communications [b]			4,8		kcps	
Chip rate tolerance, Communications			0	±1,5	%	
Digital bit jitter [c]				±5	µs	
Data rate (Manchester encoding) [d]			f_{chip} × 1/2		bps	
Preamble (leader) length including bit / byte-sync	L_{PR}	96			chips	
Postamble (trailer) length [d]	L_{PO}	2		16	chips	
Acknowledge window [f]	t_{AW}	3		50	ms	
Response delay [g]	t_{RD}	5		10 000	ms	
NOTE The Wake up chip rate has been selected in such a way, that it may be possible to derive it from the same master clock as the Communications chip rate.						
a The standard is optimized for the 868-870MHz band, but with local radio approval, it may allow for operation in other frequency bands. b The chip rate during communication deviates from the chip rate during wake up. This ensures that an ongoing transmission to another node is not detected as a wake up signal by a power-strobed unit. c The bit jitter shall be measured at the output of the micro-controller or encoder circuit.						

Characteristic	Sym	Min	Typ	Max	Unit	Remark

[d] Each bit shall be coded as 2 chips (Manchester coding)

[e] The postamble (trailer) shall consists of n=1 to 8 "ones" i.e. the chip sequence shall be n × (01).

[f] Acknowledge window: After transmitting a message the node shall be ready for the reception of an acknowledge message in less than the minimum acknowledge window. After transmitting a message the node shall at least continue receiving for the duration of the maximum acknowledge window.

[g] Response delay: After receiving a request message, the node shall not start sending the response back in less than the minimum response delay and shall start sending the response back in less than the maximum response delay.

[h] n shall be in the range 0..9

6.2.3 Receiver

The parameters for the receivers shall be as specified in Table 3.

Table 3 — Mode P, Receiver

Characteristic	Class	Sym	Min	Typ	Max	Unit	Remark
Sensitivity [b]	H_R	P_o	-105	-110		dBm	
Blocking performance	L_R		3			Class [a]	
Blocking performance [c]	M_R		2			Class [a]	
Blocking performance [c,d]	H_R		2			Class [a]	
Acceptable chip rate range		f_{chip}	4,7	4,8	4,9	kcps	~ 2%
Acceptable chip rate variation during header and frame		Df_{chip}		0	±0,2	%	
Wake up period		t_{WUP}			5000	ms	
Acknowledge delay [e]		t_{AD}	5		48	ms	
Response wait [f]		t_{RW}			21 000	ms	

NOTE The characteristics, with respect to frequencies and performance, are the same as for mode R2 in EN 13757-4.

[a] Receiver class according to ETSI EN 300 220-1:2000, 9.3.

[b] The sensitivity shall either be measured at (BER < 10^{-2}) in conducted mode as specified in ETSI EN 300 220-2:2000, 4.1, or if this is not possible then it shall be measured at (Block acceptance rate > 80 %) as specified in ETSI EN 300 220-2:2000, 4.2.

[c] Additional requirement for MR and HR receiver class: The receiver shall meet the performance criteria as specified in ETSI EN 301 489-1:2002, 9.2 and ETSI EN 301 489-3, Clause 6.

[d] Additional requirement for the HR receiver class: Adjacent band selectivity shall be > 40 dB and Adjacent channel selectivity shall be > 40 dB minimum, as specified in ETSI EN 300 220-1:2000 V1-3-1, 9.1 and 9.2 respectively.

[e] Acknowledge delay: After receiving a message, the node shall not start sending the acknowledge in less than the minimum acknowledge delay. After receiving a message, the node shall start sending the acknowledge in less than the maximum acknowledge delay.

[f] Response wait: After sending a message and expecting a response, a node shall, at the Application Layer, not time out the connection in less than the maximum response wait time. The maximum value takes into account that some units needs a wake up signal. The maximum value may be extended, after agreement with the operator.

6.3 Data encoding

6.3.1 Manchester encoding

Manchester encoding shall be used for this mode. It allows for a simple coding/decoding. Each bit shall either be encoded as "10" chip sequence representing a data value of "0" or as "01" chip sequence representing a "1". The lower frequency shall correspond to a chip value of "0".

6.3.2 Order of transmission of the encoded data

Each data byte shall always be transmitted with the most significant bit (MSB = most significant bit) first. The byte sequence of the CRC shall be transmitted with the high byte first. The byte sequence of all other multi-byte field shall be transmitted with the low byte first.

6.3.3 Wake up and preamble chip sequences

This protocol is designed for use with long lifetime battery powered meters. It is important not to activate such meters at the wrong moment. The communications part of the meter is normally asleep / unpowered. The meter shall with regular intervals listen for a dedicated wake up signal for a short time. It may, if no wake up signal is detected go asleep again.

The chip-rate for the wake up signals shall deviate from the chip-rate for normal communication. This ensures that normal data traffic is not detected as a wake up signal.

A wake up signal shall be sent before the preamble, when the sender expects the receiver to be asleep. The wake up signal shall be immediately followed by the preamble. The total preamble (header + synchronization) chip sequence for this mode is n×(01) 000111 0101 1010 0101 with n ≥ 39.

NOTE 1 In Manchester coding, the chip sequence 000111 is invalid. But it is used near the end of the header to allow a receiver to detect the start of a new or a stronger transmission. This applies even during reception of a weaker transmission. The capture effect allows efficient communication even in a channel where many weak transmitters from a large area might otherwise effectively block the reception of a nearer (stronger) transmitter. In addition it allows receivers with power strobing to distinguish safely between the start of a valid frame and an accidental “sync” sequences within an ongoing transmission.

NOTE 2 The synchronization pattern differs from that of Mode S and mode R2 of EN 13757-4.

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

6.4 Data Link Layer protocol

6.4.1 General

The protocol used shall be symmetrical, i.e. the same formatting of the data is used independent of whether it is an upstream or a downstream data transfer.

The Link Layer of EN 60870-5-2, 3.4 with the format class FT3 with the below mentioned exceptions shall be used;

— The two start characters as specified in EN 60870-5-1 6.2.4.4.2 are not used, as there is a preamble instead.

— Some of the header information, the address of the source node, extends into the second block, to allow for sufficient size address fields.

6.4.2 Frame format

A frame shall consist of at least two and optionally more blocks.

The format of the first block shall be as specified in Table 4.

NOTE 1 The size of the first block is less than 16 bytes to avoid breaking an address into two parts.

Table 4 — First block format

L-field	C-field	M1-field	A1-field	CRC-field
1 byte	1 byte	2 bytes	6 bytes	2 bytes

Where

L-field The total number of data in block 2 and onward as specified in EN 60870-5-1.

C-field The control field as specified in EN 60870-5-2, 6.1.2 (balanced transmission).

M1-fieldThe Manufacturer ID field, for the destination node, as specified in EN 13757-4:2013, 11.5.5.

A1-field: The address of the destination node.

CRC-field: The check field as specified in EN 60870-5-1 Table 1, Format Class FT3.

NOTE 2 The size of the two A-fields has been set to 6 bytes to make it compatible with the meter address format used in EN 13757-4, to be able to uniquely identify the meter by the link layer address. This makes it necessary to split the total address information across two blocks, inserting a part of the address information in the second block.

The format of the second block shall be as specified in Table 5.

Table 5— Second block format

M2-field	A2-field	CI-field	Data	CRC-field
2 bytes	6 bytes	1 byte	(7 or if it is the last block (L-9)) bytes	2 bytes

Where

M2-fieldThe Manufacturer ID field, for the source node, as specified in EN 13757-4:2013, 11.5.5.

A2-field: The address of the source node

CI-field The Control Information field.

Data Network control and application data.

CRC-field: The check field as specified in EN 60870-5-1 Table 1, format class FT3.

The format of the other optional blocks shall be as specified in Table 6.

Table 6 — Optional blocks format

Data	CRC-field
(16 or if it is the last block ((L-1) modulo 16)+1) bytes	2 bytes

Where

Data Network control and application data.

CRC-field: The check field as specified in EN 60870-5-1, Table 1

NOTE 3 The total number of blocks in a frame is limited to 16 by the size of the L-field.

6.4.3 C-field

6.4.3.1 General

For relays using the router approach, the requirements for the coding of the C-field, as specified in EN 60870-5-2, 6.1.2 shall apply. This is balanced transmission.

NOTE The definitions from EN 60870-5-2 are used in the subclauses that follow.

The format of the C-field, bit by bit shall be as specified in Figure 9.

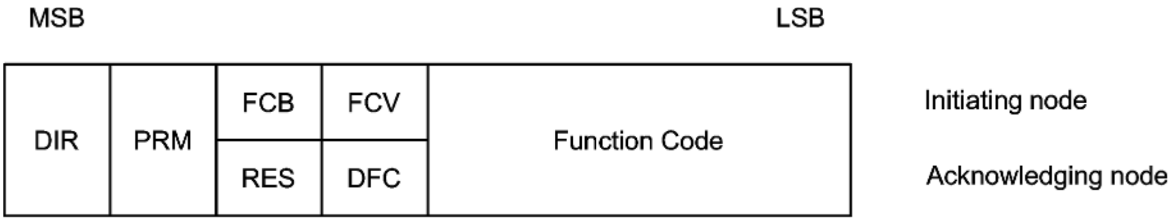


Figure 9 — C-field data format

6.4.3.2 When initiating a data exchange

When initiating a data exchange the following shall apply:

DIR – bit shall be '1' as the direction is from the initiating node.

PRM – bit shall be '1' if the direction is downstream and '0' if the direction is 'upstream'

FCB and FCV bit coding shall be as specified in EN 60870-5-2.

The Function code shall have one of the values listed in Table 7.

Table 7 — Initiating function codes

Function code [a]	Symbolic name	Function	Acknowledge
0_h	LRESET	Link reset, shall be used when the FCB bit for this link shall be reset	No
3_h	SEND	Send data, shall be used when the node sends normal data.	Yes
4_h	BCAST [b]	Broadcast data, shall be used when the node sends broadcast data.	No
6_h	INSTALL	Install information, shall be used when the node sends data and is itself in installation mode	Yes

NOTE There is no need for a REQUEST Function code at Link Layer level as requests and responses are handled at the Application Layer level.

a The value of the 4 bit Function code is specified in hexadecimal format as denoted by the trailing subscript 'h'.

b Broadcast data shall not be relayed through routers.

6.4.3.3 During acknowledge of a data exchange

When responding to a data exchange the following shall apply:

DIR – bit shall be '0' if the direction is from the responding node.

PRM – bit shall be '1' if the direction is downstream and '0' if the direction is upstream;

RES – bit shall be '0';

DFC - bit shall be '1';

Function code shall have one of the values listed in Table 8.

Table 8 — Acknowledging function codes

Function code	Symbolic name	Function
0_h	ACK	Acknowledge, shall be used when the node confirms a message with a Function code of SEND or INSTALL.
1_h	NACK	Not acknowledge, shall be used when the node rejects a message with a Function code of SEND or INSTALL.

6.4.4 M- and A-fields

The size of the first block is by EN 60870-5-1 limited to 16 bytes. This block shall according to EN 60870-5-2 include all of the address fields. This does not allow for a full 8 bytes address field. The address has been extended into the second block to allow for the use of full 8 bytes address fields. This is not fully compliant to EN 60870-5-2:1993, 3.4.

The M1and M2 field shall contain a unique User/Manufacturer identification of a node. The 15 least significant bits of these two bytes shall be formed from a three letter code, as specified in EN 13757-3. If the most significant bit of the M-field is '0' then the corresponding A-field shall be a unique (hard coded) manufacturer specified node address of 6 bytes. If the most significant bit of the M-field is '1', then the corresponding A-field may be a soft coded address. This address shall be unique within maximum range of the network. Such an address is normally assigned to the node at installation time.

A node may be multi-homed, i.e. it may respond to respond to multiple destination addresses.

NOTE The order of the M- and A-fields ensures that the receiving node is able to distinguish the destination address of the frame, as early as possible. This improves the possibility of limiting the on time and thereby the power consumption.

EN 60870-5-2 specifies that the broadcast address is an address field with all bits set to '1'. This shall, in the current context, be interpreted in the following way.

The concatenated destination M- and A-field shall have all bits set to '1' in a broadcast message. The source M-field and A-field shall be that of the sending node of the broadcast message.

6.4.5 The CI-field

The CI-field is the header of the upper layers. The use of this byte is explained in the subsequent subclauses on the Network Layer and on the Application Layer.

6.4.6 Message handling

6.4.6.1 General

The message handling requirements specified here are all at the Data Link Layer level.

6.4.6.2 Sending from an initiating node

The transmitter should, before initiating a transmission, receive on the selected channel, and ensure that a transmission is not blocking another ongoing transmission.

The initiating node shall initially send the message without a leading wake up signal.

The initiating node shall 1'st time and 2'nd time a message is retransmitted due to a NACK prepend the message with a Link Reset message. It shall not send a leading wake up signal.

The initiating node shall, 1'st time a message is retransmitted due to timeout, resend it with a leading wake up signal.

The initiating node shall, 2'nd time a message is retransmitted due to timeout, resend it without a leading wake up signal.

The initiating node shall, if the transmission has not succeeded after 3 attempts, pass a 'not success' flag to the Network Layer.

6.4.6.3 Sending from a acknowledging node

The acknowledging node shall send the acknowledge message without a leading wake up signal.

NOTE This is a reply to a node, that recently sent a message, and it should still be powered and active.

6.4.6.4 Receiving from an initiating node

When receiving from an initiating node the following shall apply;

The receiving node shall drop the frame, if the destination address, i.e. the M1- or the A1-field, is incorrect.

The node shall drop the frame if the CRC check of the first block fails.

The node shall not acknowledge a message if the Function Code does not request acknowledge, see Table 4.

The node shall reply with a NACK if the DIR bit is '0'.

The node shall reply with a NACK if the FCV / FCB control of the frame fails

The node shall reply with a NACK if the Function Code is not in the set specified in Table 4.

The node shall reply with a NACK if any of the subsequent CRC checks of the blocks fail.

The node shall, if all of the above tests are passed, reply with an ACK and forward the data to the Network Layer.

6.4.6.5 Receiving from an acknowledging node

When receiving from an acknowledging node the following shall apply;

The node shall drop the frame, if the destination address, i.e. the M1 – or the A1-field, is incorrect.

The node shall initiate retransmission if the CRC check of the first block fails.

The node shall initiate retransmission if the DIR bit is '1'.

The node shall reset the link and start a retransmission if a NACK is received.

The node shall, if all of the above tests are passed, pass an 'accepted' flag to the Network Layer.

6.4.7 Timing requirements

The timing requirements specified here are all at the Data Link Layer level.

The timing parameters referenced in this subclause are specified in Table 2 and Table 3.

A node shall when an ACK or a NACK shall be sent by the Data Link Layer, not start the reply before the minimum value of t_{AW}.

NOTE 1 This ensures that the receiver in the former transmitting node is able to settle before the message is received.

A node shall, when an ACK or a NACK shall be sent by the Data Link Layer, start the reply within t_{AD} of the end of the received message.

A node expecting an ACK or a NACK shall timeout the transfer if no data is received before the maximum value of t_{AW}.

NOTE 2 Requests and responses are handled at the Application Layer.

6.5 Network Layer protocol

6.5.1 General

This protocol shall only be used with the mode P Data Link Layer.

The presence of a CI-field specifies that higher layer data follows. The structure of higher layer protocols shall be as shown in Table 9.

A CI-field ≠ 81_h shall be used when the Network Layer is empty. An empty Network Layer may only be used when there is a direct connection between two end nodes. In this case no 'Network Layer information' is transferred and the first byte of the higher layers shall be the Application Layer CI-field.

A CI-field = 81_h shall be used when there is a Network Layer. The Network Layer information shall then be followed by a secondary CI-field, the Application Layer CI-field.

Table 9 — Higher layer format

CI	Hop info	Address 1	.....	Address n	App-CI	Application data
81_h	2 bytes	8 bytes		8 bytes	1 byte	x bytes
Network layer information					Application layer information	

6.5.2 Network Layer format

The format of the network layer information is mainly a list of intermediate routers to hop via. The format shall be as shown in Table 10.

Table 10 — Network Layer format

CI	Hop count	Current hop	Source Addr.	Interm, Addr. 1	...	Interm. Addr. n	Destin. Addr.
81_h	1 byte	1 byte	8 bytes	8 bytes		8 bytes	8 bytes

Where

CI, 1 byte Shall be 81_h, specifying that network layer information follows.

Hop count, 1 byte, The total number of hops to perform, range 1 .. 10.

NOTE 1 This field will be '1' if it is an end-to-end transfer without any intermediate nodes. The total number of address elements in the network layer information is hop count + 1 as the source address is transmitted as well.

Current hop 1 byte, The number of the next intermediate node to use as destination, range 1 .. 10.

NOTE 2 This field will have the value '1' during the first hop, i.e. when sent from the end node. It will have the value 'Hop count' during the last hop, i.e. when received by the end node.

Source Addr	8 bytes	The Data Link Layer address of the initiating end node. It shall as well be in the Network Layer data, to ensure that a response can be sent back. The field is the concatenation of the M-field and the A-field from the Data Link Layer.
Interm. Addr.1	8 bytes	Optional, the Data Link Layer address of the first intermediate node (router) to use in this transfer. It shall be empty if it is an end-to-end connection.
Interm. Addr.n	8 bytes	Optional, the Data Link Layer address of the last intermediate node (router) to use in this transfer. It is the 'Interm. Addr.1' field if there is only 1 router. It shall be empty if it is an end-to-end connection. There may be up to 9 intermediate addresses.
Destin. Addr.	8 bytes	The Data Link Layer address of the receiving end node for the data transfer.

Data in the Network Layer protocol shall not be moved as data are transferred through the network. The only parameter shall change for each hop is the 'Current hop' field. It shall be incremented. The order of the Network Layer address elements shall be reversed at the end node before a response may be sent back to the initiating node.

6.5.3 Relaying rules

These are the rules that shall be used for handling of information at the network layer, and the rules that shall be used for passing of control information from the Network Layer to the Data Link Layer:

a) The 'Current hop' shall be '1' at the initiating end node.

b) The 'Hop count' value shall be in the range 1 to 10. If the 'Hop count' value is outside this range then the frame shall be rejected.

c) If the 'Current hop' value is outside the range 1 to 'Hop Count' then the frame shall be rejected.

d) There shall be 'Hop count + 1' address element in the Network Layer data, including the Source Address and the Destination Address.

e) The Source Address may be interpreted as 'Intermediate Address 0' and the Destination Address may be interpreted as 'Intermediate Address (Hop count)'.

f) In an intermediate node (router), the Data Link Layer addresses for the next hop shall be generated in the following way:

   1) Move the information from 'Intermediate Address (Current hop -1)' to the Source Address field in the Data Link Layer;

   2) Move the information from the 'Intermediate Address (Current hop)' into Destination Address field in the Data Link Layer.

g) The intermediate (or initiating) node shall then pass the information on to the Data Link Layer, i.e. send the data.

h) The receiving node shall, if 'Current hop' = 'Hop count' pass the data on to the Application layer.

i) The receiving node shall, if 'Current hop' < 'Hop count' increment 'Current hop' and repeat from step f).

j) The sending node shall, if the Data Link Layer returns a flag of 'not success' when trying to send data perform error handling as follows:

1) If the direction of transfer is downstream, then it shall return an error message back to the Data Collecting end node;

2) If the direction of transfer is upstream, then it may optionally store the information about missing upstream connection in an error log, and shall flag that the upstream connection is faulty.

The protocol is balanced at the Data Link Layer level and at the Network Layer level, but is master driven at the Application Layer level. The meter will only send data when so requested by the Data Collecting unit. An error in the upstream path will in the downstream path either cause a timeout on the acknowledge at Data Link Layer level, or a timeout of the response at the Application Layer level. It is then up to the Data Collecting Unit to determine what to do. The intermediate node shall not queue the data at transmission errors in the upstream direction.

6.6 Application Layer protocol

6.6.1 CI-field

The CI- or Control Information-field indicates the type of application data that follows. Specific values that are described in the following sub-clauses are listed in Table 11. General data elements and manufacturer specific CI-Fields may be used in addition to the listed CI-Field values. See EN 13757-3:2013, Table 1 for such values.

Table 11 — Application Layer, Control Information field

CI value	Designation	Remarks
$6E_h$	Error reporting	Application error from device (short header)
$6F_h$	Error reporting	Application error from device (long header)
70_h	Error Reporting	Application error from device (no header)
81_h	Network Layer data	Not allowed as Application Layer data
82_h	Reserved	Reserved for Network management data
83_h	Network management Application	For management of the Network Layer

6.6.2 Error reporting service

6.6.2.1 General

A routing node shall contain an error reporting service. The node shall use the service to return error status information. Error information returned shall use a CI-field of $6E_h$, $6F_h$ or 70_h.The first byte following the CI-field is a Type field. The format of the data shall be as shown in Table 12.

Table 12 — Error status data format

CI	Type	Application data
$6E_h$/$6F_h$/70_h	XX_h	Further error information
1 byte	1 byte	n bytes

The Type field may have the values as defined in Table 13.

Table 13 — Error type

Type value	Designation	Remarks
00_h	Unspecified error	Unspecified error or data field missing
01_h	No application	Unimplemented CI – field
02_h – 09_h	Application error	Compatible with EN 13757-3
$0A_h$ – 10_h		Reserved
11_h	No function	Function in Network Management not implemented
12_h	Data error	Data to be supplied not available
13_h	Relaying error	Cannot relay data further
14_h	Access violation	Data access right violation
15_h	Parameter error	Parameter wrong or missing
16_h	Size error	The amount of data requested cannot be handled
17_h – $1F_h$		Reserved
20_h	Wrong Encryption key	Decryption fails [a]
21_h	Wrong encryption method	Encryption method not supported
22_h - EF_h		Reserved
$F0_h$		Dynamic application error [b]
$F1_h$ – FF_h	Manufacturer specific	Manufacturer specific error information

a This error code was previously defined as "Meter installation mode". It has been changed to be compatible with EN 13757–3.

b The data point is coded as a M-bus specific data point with a leading DIF/VIF. The declaration is vendor specific. The dynamic application error is limited to 7 bytes.

Detailed specification of the different types of error status is defined in the subclauses that follow.

6.6.2.2 No application

This error status shall be returned by the Application Layer, if the requested application CI-field is not implemented in the node. The type field shall be followed by a copy of the incorrect CI-field.

6.6.2.3 Application error

These error codes may be used if an EN 13757-3 Application Layer is implemented.

6.6.2.4 No function

This error status shall be returned by the Application Layer, if the requested function, that is a defined function, is not implemented in the actual Application Layer. The type field shall be followed by a copy of the not implemented function field.

6.6.2.5 Data error

This error status shall be returned by the Application Layer, if the data provided to Application Layer are incorrect.

6.6.2.6 Relaying error

This error status shall be returned by the Application Layer, if the node cannot forward data to the next node. The format of the data returned shall be as shown in Table 14.

Table 14 — Relay error format

Type value	Status	Destin Addr.	Num. fields	Interm, Addr. n	...	Interm. Addr. 1	Initiating Addr.
13_h	1 byte	8 bytes	1 byte	8 bytes		8 bytes	8 bytes

The data returned shows the path the data had traversed before relaying failed where:

Type — 13_h indication relaying error

Status — Enumerated, showing status of attempt:

- 0 no response from node, timeout three times;
- 1 Node responds, but with NAK;
- 2 Node reacts, but with error in answer.

Destin. addr — 8 bytes, the Destination Address that cannot be reached.

Num fields — 1 byte, the number of address fields that follows, including the Initiating Address. The list holds the addresses of the nodes that the frame passed on its way out, The range is 1 to 10.

Interm Addr n — 8 bytes, Intermediate Address n. The address of the current node, i.e. the node to handle the data when they 'got stuck', Shall be Intermediate Address 1 if only one relay node has been active.

Interm.Addr 1 — 8 bytes, Intermediate Address 1. The address of the first node that relayed the message.

Init. Addr — 8 bytes, Initiating Address. The address of the node that initiated the transfer, either the Data Collecting Unit or a Meter.

The minimal situation will be when an end node can only reach the first relay. Then the 'Num field' shall be '1', all but Intermediate Address field 1 shall be absent and the 'Initiating Address' will be that of the end node.

6.6.3 Network management service

6.6.3.1 General

A routing node shall contain a network management application. Data shall be passed on to the network management application, whenever the CI-field is 83_h. The format of the data shall be as shown in Table 15. The 1 byte field following the CI-field is the Function field or F-field and it defines the way data shall be interpreted.

Table 15 — Network management data format

CI	Function	Application data
83_h	XX_h	Function specific information
1 byte	1 byte	x bytes

The functions listed in Table 16 below covers the following network management requirements:

— There will be a demand for precision time tagging of information the nodes as there is a drift of the real time clock in the nodes. It shall thus be possible to set the time in the nodes, this time setting may include corrections for the delay in intermediate nodes.

— It shall be possible to generate and retrieve a list of the nodes that a gateway is able to receive data from, in order to set up the proper transmission paths.

— It shall be possible to pass on information about failures in the relaying of information through gateways. Two situations exist, failure in transferring data downstream, and failure in transferring data upstream. The purpose of such error messages is to be able to detect a failing link in order to maintain an efficient and robust data transfer network.

The F-field may have the values as defined in Table 16.

Table 16 — Function list

F-field	Designation	Remarks
00_h	Time sync	Time synchronization signal
01_h	Forward time sync	Forward time synchronization one step downward
14_h	Known nodes list	List of network nodes known to routing node
15_h	Clear nodes list	Clear content of list of nodes known to the routing node
21_h	Relay error status	Request and return of message on previous failing relaying
NOTE Handling of Relaying errors is performed by using the generic Error Reporting service with CI = 70_h and Type = 13_h.		

Values of the F-field in the range 00_h to $7F_h$ are for standardized used. Values, in this range, not listed in the table above are reserved for future use (RFU) and shall not be used. Values in the range 80_h to FF_h may be used for manufacturer specific functions.

For the F-fields listed above, the format for the application data following the F-Field and the corresponding functionality is listed below.

6.6.3.2 Time sync

This function is used when the primary station, the Data Collection Unit, or intermediate nodes want to synchronize the time in all of the nodes they send data directly to. The data format shall be as shown in Table 17.

Table 17 — Time sync data format

F-field	Delay	Year	Month	Day	Hour	Min	Sec	Time Zone
00_h	2 bytes	1 byte	1 byte	1 byte	1 byte	1 byte	1 byte	1 byte

Where

F-field 00_h indicating Time sync.

Delay: 2 bytes unsigned integer, transport delay in ms, range 0 to 64 000.

Year: 1 byte, unsigned integer, years since 2000, range 5 to 99.

Month: 1 byte, unsigned integer, range 1 to 12.

Day: 1 byte, unsigned integer range, 1 to 31.

Hour: 1 byte, unsigned integer, range 0 to 23.

Min: 1 byte, unsigned integer, range 0 to 59.

Sec: 1 byte, unsigned integer, range 0 to 59.

Time Zone: 1 byte signed, range -12 to 12, offset relative to UTC.

NOTE 1 This makes it possible to handle time zones and Daylight Saving Time.

The initiating node shall insert a value into the Delay field that corresponds to the delay from the time the clock value was read from the clock source and until the sync sequence in the preamble is transmitted.

The destination node should take into account any delay introduced by intermediate nodes. This may be done using the hop count and pre calculated values.

NOTE 2 Any intermediate nodes cannot themselves insert a delay value, as they do not analyse the content of the Application Layer data.

This command may be sent using the broadcast address as specified in EN 60870-5-2. Nodes receiving this command as a broadcast receiver shall not broadcast it further to avoid 'broadcast storms'.

NOTE 3 The use of broadcast prevents the use of acknowledge signals and thereby the confirmation of the command.

The manufacturer shall state the precision of the delay calculations in initiating as well as in intermediate nodes.

NOTE 4 Applications requiring a higher precision in the timing should select the mode Q protocol for their system.

6.6.3.3 Forward time sync

This function is used when the primary station, the Data Collection Unit, wants an intermediate node to synchronize the time in all of the nodes it sends data directly to, based on the intermediate nodes own clock. The data format shall be as shown in Table 18.

Table 18 — Forward time sync data format

F-field	Destin. Address
01_h	8 bytes

Where

F-field 01_h indicating forward time sync.

Destin Addr: 8 bytes, destination address to use when forwarding the time synchronization.

The receiving node shall send a time synchronization message to the nodes one level further away from the Data Collecting Unit. The destination address shall be as specified in the data field.

This command shall be sent using the broadcast address as specified in EN 60870-5-2 if the Destin. Address field is 'all ones'.

NOTE The use of broadcast prevents the use of acknowledge signals and thereby the confirmation of the command.

6.6.3.4 Known nodes list

There is a need for access to information about which routers that are able to receive from which other routers and end nodes in order to be able to maintain a list of hops to use in the primary station. This function requests a router to return information about the end-nodes and routers it is able to receive data from. The list contains the addresses of all the nodes known and may as well contain a quality indicator for each of them. The format of the request as well as the response is listed below.

The format of the request shall be as shown in Table 19.

Table 19 — Known nodes request format

F-field	Modifier
14_h	1 byte

Where

F-field 14_h indicating known nodes list.

Modifier: 1 byte, with the following bit fields;

Bit 7 0 = return first block from list;

1 = return subsequent block from list.

Bit 6 0 = return only node address information;

1 = return node address and quality information.

Bit 5..0 Reserved for future use, shall be 0 when not used.

The format of the response shall be as shown in Table 20.

Table 20 — Known nodes response format

F-field	Count/ modifier	Address 1	Quality indicator 1	...	Address n	Quality indicator n
14_h	1 byte	8 bytes	1 byte (opt)		8 bytes	1 byte (opt)

Where

F-field: 14_h Indicator of function type.

Count/Modifier: 1 byte, with bit fields;

Bit 7 0 = first block from list;

1 = subsequent block from list.

Bit 6 0 = only node address information returned;

1 = node address and quality information returned.

Bit 5 0 = more data available;

1 = last block from list.

Bit 4..0 Range 0 to 27 number of address element sets (Address and Quality indicator) returned in this frame.

Address 1: 8 bytes, the full address of the first address in this frame from the list of nodes known to this relay.

Quality indicator 1: 1 byte, range 0 to 255. Optional parameter only returned if bit 6 of the count/modifier field is 1. It indicates the quality of the receive-connection from the node to the relay. A large value indicates a good connection and a small value a bad connection. The algorithm to be used for generation is outside the scope for this European Standard.

Address n: 8 bytes, the full address of the last address in this frame from the list of nodes known by this relay node

Quality indicator n: 1 byte, range 0 to 255. Optional parameter only returned if bit 6 of the count/modifier field is 1. It indicates the quality of the receive-connection from the node to the relay. A large value indicates a good connection and a small value a bad connection. The algorithm to be used for generation is outside the scope for this standard.

NOTE The frame size at the link layer is the limiting factor for the number of address element sets in a block.

6.6.3.5 Clear nodes list

There is a need for a possibility of regenerating the information about which nodes a gateway is able to receive from in order to be able to maintain a list of hops to use in the primary station. This function requests a gateway to restart the collection of this information. This will clear the internal list of known nodes. The format of the command shall be as shown in Table 21.

Table 21 — Clear nodes list command format

F-field
15_h

F-field 15_h indicating clear nodes list

6.6.3.6 Relaying error status

An error while transferring data upstream is at the same time a fault in the transmission path for error information. This inhibits the transfer of error information to the primary node. The router shall handle this error condition in two steps. It shall at first store the error status locally and await restoration of the transmission path. Upstream data transfer is the response to a request. The primary station will detect the missing response and shall retry the request. The primary station shall if this fails try to establish an alternate transmission path to the router.

The router may, if the error condition remains for a prolonged time, switch back to installation mode, and send a unsolicited installation request to establish an alternate path from the router to the primary station. This condition can be used to establish an alternate path from the router to the primary station.

NOTE 1 The mechanism for storing the error status locally and for establishing alternate transmission paths is outside the scope of this standard.

Once the transmission path has been re-established the information about the error condition may be retrieved by the primary station. The format of a relaying error status, the request as well as the response is listed below:

The format of a relaying error status request shall be as shown in Table 22.

Table 22 — Relaying error status request format

F-field	Modifier
21_h	1 byte

Where

F-field: 21_h Indicator of function type.

Modifier: 1 byte, with bit fields;

Bit 7 0 = return first block from list;

1 = return subsequent block from list.

Bit 6 0 = don't return time tag for relaying error data;

1 = return time tag for relaying error data.

Bit 5 0 = don't return application data for relaying error data;

1 = return application data for relaying error data.

Bit 4..0 0, reserved for future use.

The format of a relaying error status response shall be as shown in Table 23.

Table 23 — Relaying error status response format

F-field	Count/ Modifier	Time tag 1	Destin. Addr. 1	App. data 1	...	Time tag n	Destin. Addr. n	App. data n
21_h	1 byte	7 bytes	8 bytes	n bytes		7 bytes	8 bytes	n bytes

F-field: 21_h Indicator of function type.

Count/ Modifier: 1 byte, with bit fields;

Bit 7 1 = Time tag is returned for data;

0 = No time tag is returned for data.

Bit 6 0 = Application data is returned;

1 = No application data is returned.

Bit 5 1 = last block from list;

0 = more data available.

Bit 4..3 Reserved for future use, shall be 0.

Bit 2..0 Number of error data sets, range 0 to 7

Time tag 1: 7 bytes, optional, the time when the first transmission error occurred. Format as used for the 'Time sync' function in 6.6.3.2

Destin. Addr. 1: 8 bytes, the full address of the node that could not be reached, from the first error,

App. Data 1: n bytes, optional, the application data that could not be transferred, from the first error.

Time tag n: 7 bytes, optional, the time when the last transmission error occurred. Format as used for the 'Timesync' function in 6.6.3.2.

Destin. Addr. n: 8 bytes, The full address of the node that could not be reached, from the last error,

App. Data n: n bytes, optional, the application data that could not be transferred, from the last (most recent) error.

The capability of returning time tag for the relaying error is an optional capability that may be implemented.

The capability of returning a copy of the application data from the relaying error is an optional capability that may be implemented.

A Count / Modifier of 00_h and no further data shall be returned if no error condition has occurred.

NOTE 2 The number and structure of error data stored in the node for later retrieval is outside the scope of this standard.

NOTE 3 The frame size at the link layer may be the limiting factor for the number of error data transmitted in a block.

7 Mode R2, protocol using gateways

7.1 General

This mode is no longer a part of this European Standard. The update of the Link Layer protocol in EN 13757-4 makes mode R2 incompatible with the gateway protocol specified in previous version of this standard.

8 Mode Q, protocol supporting precision timing

8.1 General

This protocol is applicable to communication between nodes requiring and supporting precision timing based on dynamic delay handling.

The protocol is optimized for battery operated units with power strobed radio unit.

8.2 Physical Layer protocol

8.2.1 General

All the parameters shall, at the minimum, conform to ETSI EN 300 220, even if some applications may require extended temperature or voltage range. The channel and frequency band shall be as specified in Table 24.

Table 24 — Mode Q, General

Characteristic	Min	Typ	Max	Unit
Frequency band [a]	868,0		868,6	MHz
Channel spacing [a]		60		kHz
NOTE The characteristics are, for the SRD band, identical to the characteristics for the S and R2 modes in EN 13757-4				
[a] The standard is optimized for the 868-870MHz band, but with local radio approval, it may allow for operation in other frequency bands and with other channel spacing.				

8.2.2 Transmitter

The parameters for the transmitters shall be as specified in Table 25.

Table 25 — Mode Q, Transmitter

Characteristic	Sym	Min	Typ	Max	Unit	Remark
Centre frequency [a]			868,030 + n × 0,06 [h]		MHz	
Transmitter duty cycle [b]				1	%	
Frequency tolerance [a] (meter / other device)			0	±17	kHz	~20ppm
FSK Deviation [a]		±4,8	±6	±7,2	kHz	
Bit rate, Wake up [c]			3,12		kbps	
Bit rate tolerance, Wake up			0	±2,5	%	
Wake up signal duration	t_{WD}	5 200		6 000	µs	
Bit rate Communications [c]			4800,00		bps	
Bit rate tolerance, Communications			0	±100	ppm	
Digital bit jitter [d]				±5	µs	
Preamble (leader) length including bit / byte-sync	L_{PR}	160			bits	
Postamble (trailer) length [e]	L_{PO}	2		16	bits	
Acknowledge delay [f]	t_{AD}	20		30	ms	
Idle detect [g]	t_{ID}	40		1 000	ms	

NOTE The Wake up bit rate has been selected in such a way, that it may be possible to derive it from the same master clock as the Communications data rate.

[a] The standard is optimized for the 868-870MHz band, but with local radio approval, it may allow for operation in other frequency bands with other channel bandwidths.

[b] Duty cycle shall be as defined by ETSI EN 300 220-1 in the SRD bands. It may with local radio approval allow for other transmission levels and duty cycles in other frequency bands.

[c] The bit rate during wake up deviates from the bit rate during communication, to conserve energy. The difference in bit rate ensures that an ongoing transmission to another node is not detected as a wake up signal by a power-strobed unit.

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

[e] The postamble (trailer) shall consists of n=1 to 8 "01" i.e. the bit sequence shall be n × (01).

[f] Acknowledge delay: After receiving a data frame, a node shall not start sending the acknowledge frame in less than the minimum acknowledge delay. After receiving a data frame, a node shall start sending the acknowledge frame in less than the maximum acknowledge delay.

[g] Idle detect: Prior to transmitting a data frame, a node shall listen and not detect any transmissions for at period of at least minimum Idle detect time before transmitting. A node may start transmitting a data frame, if it has listened for more than maximum Idle detect without detecting an idle channel.

[h] n shall be in the range 0..9

8.2.3 Receiver

The parameters for the receivers shall be as specified in Table 26.

Table 26 — Mode Q, Receiver

Characteristic	Class	Sym	Min	Typ	Max	Unit	Remark
Sensitivity [b]	H_R	P_o	-105	-110		dBm	
Blocking performance	L_R		3			Class [a]	
Blocking performance [c]	M_R		2			Class [a]	
Blocking performance [c,d]	H_R		2			Class [a]	
Acceptable bit rate range		f_{bit}	4 799,52	4 800,00	4 800,48	bps	±100 ppm
Wake up period		t_{WUP}			5 000	ms	
Wake up time-out [e]		t_{WUT}	16 000			ms	
Acknowledge window [f]		t_{AW}	16		50	ms	
Acknowledge time-out [g]		t_{AT}	200			ms	

NOTE The characteristics, with respect to frequencies and performance, are the same as for Mode R2 in EN 13757-4.

a Receiver class according to ETSI EN 300 220-1:2000, 9.3.

b The sensitivity shall either be measured at (BER < 10^{-2}) in conducted mode as specified in ETSI EN 300 220-2:2000, 4.1, or if this is not possible then it shall be measured at (Block acceptance rate > 80 %) as specified in ETSI EN 300-220-2:2000, 4.2.

c Additional requirement for MR and HR receiver class: The receiver shall meet the performance criteria as specified in ETSI EN 301 489-1, 9.2 and ETSI EN 301 489-3, Clause 6

d Additional requirement for the HR receiver class: Adjacent band selectivity shall be > 40 dB and Adjacent channel selectivity shall be > 40 dB minimum, as specified in ETSI EN 300 220-1:2000 V1-3-1, 9.1 and 9.2 respectively.

e Wake up time-out: After receiving a wake up signal or a valid data frame, the receiver shall stay powered on for at least the minimum wake up time-out.

f Acknowledge window: After transmitting a data frame a node shall be ready for the reception of an acknowledge frame in less than the minimum acknowledge window. After transmitting a data frame a node shall at least continue receiving for the duration of the maximum acknowledge window. A node may use other means than the reception of an acknowledge frame as the detection of the reception of a data frame.

g Acknowledge time-out: After transmitting a data frame, and waiting for an acknowledge, a node may time out the connection if no acknowledge is received within the minimum Acknowledge time-out.

Information in this subclause is limited to the timing requirements at the Physical Layer. Requirements for routing timing are specified in the Network Layer subclause. Requirements for End-to-end timing are specified in the Application Layer subclause.

8.3 Data Encoding

8.3.1 NRZ encoding

The individual data bits are encoded using Non Return to Zero coding. This is made possible using the transceiver chips with digital signal processing. A bit of '0' shall correspond to the lower frequency in the FSK.

8.3.2 Order of transmission of the encoded data

Each data byte shall always be transmitted with the least significant bit (LSB = least significant bit) first. The byte sequence of the CRC shall be transmitted with the high byte first. The byte sequence of all other multi-byte field shall be transmitted with the low byte first.

8.3.3 Wake up and preamble bit sequences

This protocol is designed for use with long lifetime battery powered meters. It is important not to activate such meters at the wrong moment. The communications part of the meter is normally asleep / unpowered. The meter shall with regular intervals listen for a dedicated wake up signal for a short time. It may, if no wake up signal is detected go asleep again.

The bit rate for the wake up signals shall deviate from the bit rate for normal communication. This ensures that normal data traffic is not detected as a wake up signal. A wake up signal shall be sent before the preamble, when the sender expects the receiver to be asleep. The wake up signal shall be immediately followed by the preamble. The total preamble (header + synchronization) chip sequence for this mode is n×(01) 0001 1101 0110 0110 0110 1101 0011 1001 with $n \geq 64$.

NOTE 1 The long header makes it possible for the receiver to adjust its centre frequency during this period.

The Duration of the header in the preamble shall be limited to $n = 64$ during a search frame to ensure that the transmission is within the specified time slot.

NOTE 2 The synchronization method differs from that of modes P, S and R2.

All chips of each frame, including optional wake up signal, pre- and postamble shall form an uninterrupted bit sequence.

8.4 Data Link Layer protocol

8.4.1 General

The protocol used shall be symmetrical, i.e. the same formatting of the data is used independent of whether it is an upstream or a downstream data transfer.

8.4.2 Frame format

8.4.2.1 General

Two types of frames exist, a data frame and an acknowledge frame. The format of the frames shall be as specified in Table 27 and Table 28 below.

Table 27 — Data Link Layer frame format, Data frame

L-field	DA-field	SA-field	FC-field	DLY-field	Data-field	FCS
1 byte	7 bytes	7 bytes	1 byte	2 bytes	n bytes	2 bytes

Table 28 — Data Link Layer frame format, Acknowledge frame

L-field	DA-field	SA-field	FC-field	FCS
1 byte	7 bytes	7 bytes	1 byte	2 bytes

Where

L-field: The length field.

DA-field: The destination address.

SA-field: The source address.

FC-field: The frame control field.

DLY-field: The delay field, used for the dynamic delay calculation.

Data-field: Data for Network Layer and Application Layer.

FCS: Frame Check Sequence.

8.4.2.2 L-field

The L-field specifies the length of the frame in bytes. The length of the frames shall include the full frame, starting with the synchronization pattern and including the FCS. The valid range of the L-field shall be 18 – 255.

8.4.2.3 SA- and DA-field

The length of the DA and SA-fields shall be 7 bytes. The SA field designates the Data Link Layer address of the node sending a frame. The DA field designates the Data Link Layer address of the node(s) to receive the frame.

The address may be one of the following four types:

— Device address, i.e. the address specifies a hardware address of a specific node. A device address is identified by the bits of the most significant byte of the address being '0xxx $xxxx_b$'. Byte 4 and 5 of the address may have two formats. If the most significant bit of byte 5 is '1' then the format of the remainder of the two bytes is free. If the most significant bit of byte 5 is '0' then the remainder of the two bytes shall contain a User / Manufacturer ID. This User / Manufacturer ID shall be encoded as specified in EN 13757-3:2013, 5.6.

— Short form address, i.e. transmission of data with a partial address. This type of addressing is used when routing packet through multiple hops to conserve packet size. A short form address is identified by the bits of the most significant byte, byte 1, being '10xx $xxxx_b$' and byte 4 and 5 being FF FF_h. A node receiving a frame with a short form address shall process the frame if the reminder of byte 1 and byte 2 and 3 of the DA-field match the 'address 'mask' of the node and byte 6 and 7 match a hardware address of the node. A node transmitting a frame shall set byte 1 to '10xx xx_b' and then insert its own address mask in the remainder of byte 1 and byte 2 and 3 and 'FF FF_h' in byte 4 and 5.

— Multicast address, i.e. the address specifies a group of nodes that all shall receive the frame. A multicast address is identified by the bits of the most significant byte of the address being '11xx $xxxx_b$'. A node receiving a frame with a multicast address shall process the frame if the remainder of byte 1 and byte 2 and 3 of the DA-field match the 'address mask' of the node. Byte 4, 5, 6 and 7 of the DA-field are 'do not care' elements when receiving and shall be sent as FF FF FF FF_h.

— Broadcast address, is a special version of the multicast address. It specifies that all nodes receiving this frame shall process the frame. The broadcast address is identified by all bits in the DA-field being '1', i.e a DA of FF FF FF FF FF_h.

A node shall support all four types of addresses.

A node shall, when replying with an acknowledge frame, use the actual source and destination address from the initial data frame as the destination and source addresses.

NOTE 1 A node may be multi-homed, i.e. it may respond to multiple devices and short form addresses.

NOTE 2 The size of the address field has been chosen as a trade off between the size of the address space, and the amount of space in the frame used for address information, especially when routing multi-hop transmissions.

8.4.2.4 The FC-field

The FC-field is a 1 byte field. The format shall be as shown in Table 29. It specifies how the frame shall be processed at the Data Link Layer level. It contains the following sub-fields; where bit 7 is the most significant bit.

Table 29— FC field structure

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1-0
Data	Acknowledge	Reserved	Direct	Search	Route Request	Reserved

Bit 7: Data frame. The bit shall be set to '1' when a data frame is transmitted, and shall be set to '0' when an acknowledge frame is transmitted.

Bit 6: Acknowledge at the data link layer. The bit shall be '0' in an acknowledge frame. The bit shall, in a data frame, be set to '1' when a acknowledge frame shall be sent back from the receiver(s). The bit shall, in a data frame be set to '0' when the receiving node(s) shall not send an acknowledge frame. The transmitting node shall not wait for an acknowledge frame if this bit is '0'.

Broad- and multicast frames should in general not be acknowledged.

Bit 5: Reserved for future use. The bit shall be set to '0' when transmitted, and shall be a "do not care" bit during reception.

Bit 4: Direct connection indicator. The bit shall be '1' when the end nodes are communication directly without any intermediate nodes and without any other Network Layer information. The bit shall be '0' when the end nodes are performing a routed communication through intermediate nodes. The field of the Network Layer header shall not be implemented if the Direct connection bit is '1'.

Bit 3: Search for other nodes. This bit shall be '1' when the frames transmitted are a part of a 'search for known nodes' sequence'. The bit shall be '0' for all other condition.

Bit 2: Signal to receiving routers that this is a Direct frame that shall be forwarded upstream as a routed frame, if a route to an upstream end-node exists in the receiving router. This bit and the Direct bit shall both be '1' if the frame is to be forwarded. If the Direct bit is '0' this bit shall be '0' as well.

Bit 1-0: Reserved for future use. The bit shall be set to '0' when transmitted, and shall be a "do not care" bit during reception.

8.4.2.5 The DLY field

This field shall only be present in a data frame. The DLY field holds information about the incremental delay of a frame, as it is being transmitted between nodes. The two bytes shall be interpreted as an unsigned integer. The integer value shall be the incremental delay of the frame, measured in ms. The incremental delay shall be the delay of the synch byte of a frame, relative to the time when the Application Layer data in the frame was generated in the sending end-node.

If the content of the DLY field has no valid value then it shall be set to FF FF_h during transmission and be "do not care" information during reception. If an overflow condition has occurred in the calculation of the DLY information, then the value shall be set to FF FE_h during transmission.

NOTE 1 The way to handle the reception of an overflow condition is outside the scope of this standard.

The incremental delay shall, for an initiating end node, be the delay from the time the packet was generated in the Application Layer to the time when the synch pattern is transmitted at the Physical Layer.

For an intermediate (routing) node, the delay from the time the synch pattern was received at the Physical Layer to the time when the synch pattern is to be transmitted again shall be added to the incremental delay value in the frame.

The manufacturer shall state the accuracy of the delay calculation of the product.

NOTE 2 The DLY field is information related to the Application Layer, but it cannot be calculated in advance. It has to be calculated on the fly. This is the reason of placing it in the Data Link Layer header.

The value shall reflect whether or not a wake up header is transmitted. The value shall be updated when a retransmission is performed. The value shall be updated for each intermediate node in a route.

8.4.2.6 The Data field

This field shall only be present in a data frame. The data field holds information to be processed by the Network Layer and the Application Layer.

8.4.2.7 The FCS

The FCS or Frame Check Sequence ensures the integrity of the data. The FCS shall be the CRC-16 ($X^{16} + X^{12} + X^{5} + 1$) as specified in RFC 1662. The FCS shall cover all information from the L-field and to the Data field (data) / FC field (acknowledge).

8.4.3 Normal Data Link Layer frame handling

8.4.3.1 General

This subclause specifies the normal frame handling requirements at the Data Link Layer level. The basic flow is that a transmitting node sends a data frame to a receiving node. The receiving node may then send an acknowledge frame.

8.4.3.2 Sending a data frame

A node shall, before initiating a data frame transmission, receive on the selected channel, and ensure that the activation of a transmission is not blocking another ongoing transmission. See Table 25, Idle detect.

A node should, when sending an initial multicast or broadcast frame prepend the data frame with a wake up signal.

The sending node shall, when sending a routed frame, initially send the frame without a leading wake up signal.

A node shall when a frame is retransmitted due to timeout, resend the frame with a leading wake up signal.

A node shall, if the transmission has not succeeded after 4 attempts, pass information on this to the upper layers.

8.4.3.3 Sending an acknowledge frame

The receiving node shall, if the Acknowledge bit in the FC field is '1' send an acknowledge frame. The acknowledge frame shall be sent with the Acknowledge and Time info bits of the FC field set to '0'. There shall be no DLY or data field in an acknowledge frame.

NOTE 1 There is no capability of returning a 'non- acknowledge' frame. Non-acknowledge is handled by using time-out.

An acknowledge frame shall be sent without a leading wake up signal.

NOTE 2 This is a reply to a node, that recently sent a data frame, and the node should still be powered and active.

8.4.3.4 Receiving a data frame

When receiving a data frame the following shall apply;

a) The node shall drop the frame, if the destination address is not one of the addresses of the node.

b) The node shall drop the frame if the FCS of the frame fails.

8.4.3.5 Receiving an acknowledge frame

When receiving an acknowledge frame the following shall apply:

a) The node shall drop the frame, if the destination address is not the source address from the corresponding data frame.

b) The node shall drop the frame if the FCS fails.

c) The node shall, if all of the above tests are passed, pass the acknowledge information on to the Network Layer, without error status.

NOTE The node may use other means than an acknowledge frame, as the detection of the correct reception of a data frame.

d) The manufacturer of a node shall state any alternative methods used to detect the acknowledgement of a data frame.

8.4.3.6 Normal timing requirements

The timing requirements specified here are all at the Link Layer level;

a) The timing parameters referenced in this subclause shall be as specified in Table 25 and Table 26.

b) A node shall when sending an acknowledge frame not start the reply before the minimum value of t_{AD}.

NOTE 1 This ensures that the receiver in the former transmitting node is able to settle before the message is received.

c) A node shall, when sending an acknowledge frame, start the reply within the maximum value of t_{AD} after the end of the data frame.

d) A node expecting an acknowledge frame shall timeout the transfer if no data has been received within the maximum value of t_{AT}. Timeout may generate a retransmission as specified in 8.4.3.2.

NOTE 2 Timing of requests and responses are handled at the Application Layer.

8.4.4 Search Link Layer frame handling

8.4.4.1 General

Special Link Layer frame handling shall be used when searching for known nodes.

A node will activate the search when it receives a 'Generate known nodes' request, see 8.6.5.4. When searching for knows nodes some special conditions shall be present.

a) All nodes (to be interrogated) shall have an internal flag 'has replied' that hold the state about whether or not the node shall respond to the search request.

b) Multicast or broadcast and direct connection (without a Network Layer) shall be used.

c) The nodes shall not respond immediately but in different time slots.

d) The format of the frames differs slightly from the format used for normal data transfer.

8.4.4.2 Frame formats

The command from the searching node shall be framed in a normal Data Link Layer data frame. The frame shall be a multi- or broadcast frame. The frame shall be sent with a wake up signal. The FC field of the frame shall be set to '1001 0000_b'. The data field of the frame shall have the format as specified in Table 30.

Table 30 — Search request data field format

Search Control	Target SNR	Address list
1 byte	1 byte	N × 7 bytes

Where

Search control: Control byte with the following fields

Bit 7: '0' = No activity, '1' = Initiate search,

Bit 6-0: Reserved for future use, shall be '0' during transmission and "do not care" during reception.

Target SNR: Target Signal to Noise Ration threshold in the receiver, expressed in dB

Address list: List of nodes already registered.

The nodes responding shall reply with a normal Link Layer data frame. The frame shall be a point-to-point frame. The FC field shall be set to '1001 0000_b'. The data field of the frame shall have the format as specified in Table 31.

Table 31 — Search response data field format

SNR level
1 byte

Where

SNR level: The Signal to Noise Ration of the signal when receiving the request.

8.4.4.3 Search sequencing

The sequencing of the search for known nodes shall be as follows:

a) The requesting node shall send the initial search request. The 'Initiate search' bit of 'Search Control' shall be set. The Target SNR shall be set to the first value in the SNR-list from the 'Generate known nodes list' commands, see 8.6.5.3. The device address of any nodes that shall not reply to the search shall be included in the address list.

b) The surrounding nodes shall read the request. They shall terminate the processing of the request and drop the frame, if the Signal to Noise Ratio of the received signal is less that the Target SNR. They shall clear their internal 'has replied' flag if the 'Initiate search' bit in the request is set. They shall set their internal 'has replied' flag if their device address is included in the address list of the request. They shall, if their internal 'has replied' flag is cleared, select a random reply time slot, and reply with a response, formatted as specified above.

c) The requesting node shall collect the information from the different time slots. It shall for each new response store the device address and the bidirectional SNR for the connection. The composite SNR is the minimum of the SNR returned by the responding node, and the measured SNR of the received frame. It shall, if new responses are received, not update the Target SNR values. It shall, if no responses from new nodes are received, update the Target SNR value to the next (lower) value in the SNR-list. The requesting node may set the 'Initiate search' bit in a second cycle, but shall clear the 'Initiate search' bit in subsequent cycles. The address list shall be updated to contain the device addresses of the devices detected in this cycle. After this, the node shall send a new request.

Experience has shown, that there may be a big difference in SNR in the two directions. The quality of a link is no better than the worst case SNR of the link. Therefore the minimum of the two SNR´s shall be used.

d) The surrounding addressed nodes shall process the second and following request as in b).

e) The requesting node shall terminate the cycle when a request with either Target SNR of '0' or with the 5'th value from the SNR-list has been performed more than 'Stop Condition' times.

8.4.4.4 Search timing requirements

The timing requirements for the search Link Layer actions are specified in Table 32.

Table 32 — Search timing

Characteristic	Symbol	Min	Typ	Max	Unit
Number of time slots	N_{TS}		24		
Duration of time slot	t_{TS}	118	120	122	ms
Response within time slot	t_{TR}	20		30	ms
Cycle time	t_{TC}	3 500		5 000	ms

8.5 Mode Q, Network Layer protocol

8.5.1 General

This Network Layer protocol shall only be used together with the mode Q Link Layer.

The presence in the Data Link Layer of bit 7 in the FC-field of '1' specifies that higher layer data follows. This is Network Layer and Application Layer information.

The presence in the Data Link Layer of bit 4 in the FC field of '1' specifies that a direct connection is used, and that no Network Layer is used, and that the Network header shall be empty.

The Network Layer supports the routing of packets through a network on a hop-by-hop basis. The maximal route length supported is 10 hops.

NOTE 10 hops correspond to 11 nodes in all, and 9 intermediate nodes.

The structure of the Network Layer information and the Network Layer protocol are specified in the following.

8.5.2 Network layer format

8.5.2.1 General

The format of the Network Layer information, a packet, is the Network Layer header and the Application Layer data. The Network Layer header is mainly a list of intermediate nodes to route through. The format shall be specified in Table 33.

Table 33 — Network Layer information format

NCtrl	TID	Destin.	Source	TTL	SNR	Nodes	Current	Addr. List	App. data
1 byte	1 byte	7 bytes	7 bytes	1 byte	1 byte	1 byte	1 byte	m × 2 bytes	n bytes

Where

NCtrl,	Network Control
TID,	Transfer Identification
Destin,	Destination address, end node
Source,	Source address, end node
TTL,	Time to live
SNR,	Signal to noise ratio
Nodes,	Total number of nodes involved, number of hops +1
Current,	Current node
Addr.List,	List of addresses of nodes
App. data,	Application Layer data.

Data in a network layer packet shall not be moved around as data are transferred through the network. The only fields that shall be modified for each hop are the 'Time to live' and 'Current hop' fields.

8.5.2.2 Network Control

The Network Control field is a bit mapped one byte field. It specifies additional information at the Network Layer level. The bit positions inside the field are defined in Table 34 below.

Table 34 — Network Control field structure

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
RFU '0'	Req./resp	Error	Agg.SNR	RFU '0'	RFU '0'	RFU '0'	RFU '0'

Positions marked as 'RFU' in Table 34 above are reserved for future use and shall have a reserved value as specified.

Request/Response, bit number 6, is the request / response indicator. The bit shall be '1' when data is transmitted downstream, i.e. in the direction from the Data Collecting Unit to the Meter. Data sent in this direction is a 'request'. The bit shall be '0' when data are transmitted upstream, i.e. in the direction from the Meter to the Data Collecting Unit. Data sent in this direction is a 'response'.

Error indicator bit number 5. The bit shall be '1' in messages containing error information. It shall be '0' in all other messages.

Agg. SNR, bit number 4. This bit specifies the way the Signal to Noise Ratio for a route is to / has been measured. The bit shall be set to '1' if the SNR aggregated i.e. the worst case (minimum) value detected along the route. The bit shall be set to '0' if the SNR reported is the SNR measured on the hop most downstream on the route, i.e. closest to the metering unit.

NOTE Measuring SNR for the individual hops makes it possible to achieve a better knowledge of the routing capabilities in the network.

8.5.2.3 Transfer Identification

The Transfer Identification is a one byte field interpreted as an unsigned integer. It is generated by the end node initiating a request (the Data Collection Unit). It is incremented for each new request sent to the network. End nodes initiating a response to a request shall copy the Transfer Identification into the response. The value '0' for the TID shall not be used for a normal Application Layer request/response. End nodes initiating un-requested messages shall use a TID of ‘0’.

NOTE The use of a Transfer Identification makes it possible to detect and filter out duplicated packets at the Network Layer and makes it possible for the application to link the response to a specific request.

8.5.2.4 Destination address

This is the address of the receiving end node. The structure of this address shall be as specified in 8.4.2.3. This shall identify the receiver of the message at the Application Layer level.

8.5.2.5 Source address

This is the address of the initiating end node. The structure of this address shall be as specified in 8.4.2.3. This shall identify the sender of the message at the Application Layer level.

8.5.2.6 Time to live

The Time to live field is a one byte field. It is a ‘timeout’ function at the network level. It shall be interpreted as an unsigned integer. It shall be in the range ‘1’ to ‘10’. The use of this field is specified in 8.5.4.

8.5.2.7 Signal to Noise Ratio

The SNR field is a one byte field. It shall be interpreted as an unsigned integer. It is reserved for network management purpose. It is used for collecting information about the Signal to Noise ratio in the network A large value shall indicate a high signal to noise ratio and a low value a low signal to noise ratio. The value should be the actually measured Signal to Noise Ratio in dB on the most recently received data frame.

The capability of measuring the SNR should be implemented in a node. The manufacturer shall state whether or not this capability is implemented in a node. The manufacturer shall, if the capability is implemented, state how to interpret the value. Nodes not implementing this capability shall use a default value of '255.'.

SNR shall be measured bi-directionally, i.e. both in the upstream, and in the downstream direction.

An end node receiving a data frame shall record the measured SNR of the transmission.

If bit 4 of the Network Control field is '1', then the node shall compare the measured value to the value in the received data frame. The value in the data frame shall be updated with the recorded value, if the recorded value is less that the received value, i.e. a worst case value is generated.

If bit 4 of the Network Control field is '0', the transfer is in the upstream direction, and the hop is not the most downstream hop in the route, then the node shall just pass on the current value in the data frame.

If bit 4 of the Network Control field is '0', and the hop is the most downstream hop in the route, then the node shall update the value in the data frame with to the measured value.

8.5.2.8 Nodes

The Nodes field is a one byte field. It shall be interpreted as an unsigned integer. The value designates the total number of nodes in the route, excluding the end nodes. The value shall be in the range 0 to 9. The use of this bit is specified in 8.5.4. End nodes responding to a request shall copy the value into the response.

NOTE A value of '0' corresponds to a direct connection between two end nodes.

8.5.2.9 Current

The current node field is a one byte field. It shall be interpreted as an unsigned integer. The value designates the current sending node in the routing from end node to end node. The value shall be in the range 0 to 10. It is a pointer into the address list. The use of this field is specified in 8.5.4.

The value shall, when sending downstream, be set to ‘1’ by the initiating end node (the Data Collecting Unit) and be incremented for each hop by the intermediate nodes. The value shall, when sending upstream, be set to ‘Nodes’ by the initiating end node (the Meter) and be decremented for each hop by the intermediate nodes.

NOTE This makes it possible to have a static address list of routes, independent of the direction of the transfer.

8.5.2.10 Address list

This field is a sequence of 2 bytes fields. The number of fields shall be equal to the value of the ‘Nodes’ field. Each 2 bytes field is an abbreviated form of the full 7 bytes address of a node. The conversion from 2 bytes to 7 bytes format is specified in 8.5.3. The first element in the list shall be the abbreviated address of the routing node closest to the upstream end node. The last element in the list shall be the abbreviated address of the routing node closest to the downstream end node.

NOTE This list may be empty, if two end nodes communicate directly.

8.5.3 Address conversion rules

Node addresses exist in a full and in an abbreviated form. The full address is a 7 bytes field. An abbreviated address is a 2 bytes field. A full address may be converted to an abbreviated address and an abbreviated address may be converted special full address named a short form address.

An abbreviated address shall be generated from a full address by extracting the two least significant bytes of the full address.

A short form address shall be generated by prepending to the abbreviated address with a 5 bytes address. The first byte (most significant) shall have the form '10xx xx_b'. This shall be followed by the 'address mask' of the node (in bytes 1, 2 and 3). Byte 4 and 5 shall be 'FF FF_h'. See 8.4.2.3 for more information.

A multi-homed node can have multiple address masks. A multi-homed node shall use the address mask matching when receiving as the address mask used when transmitting the data to the next node.

An initiating node shall use the address mask of the source address.

8.5.4 Routing rules

8.5.4.1 General

These are the rules to be used when handling information at the Network Layer, and the rules to be used when passing of information from the Network Layer to the Link Layer. The rules are specified for the individual types of nodes. An initiating end node starts the transfer to a receiving end node. The transfer may pass through a number of intermediate nodes on its route from one end node to another end node.

The structure used is a master/slave structure, i.e. a central node will request information from peripheral nodes, and the peripheral nodes will then revert with a response. There is aside of that a special mode, unsolicited response, where a peripheral node will send information to the central node, without any prior request. This mode may be used when sending alarms and when initially connecting to the network.

NOTE This subclause is not applicable to nodes using a non-routed transfer i.e. a direct connection.

8.5.4.2 Rules for an initiating node

a) The fields 'Network Control, 'TID', 'Source', 'Destination', 'Nodes' and 'Address list' shall only be modified by the initiating node. Other nodes shall not modify these fields.

b) The setting of the 'TID' field depends on the direction of transmission and the type of message.

- The 'TID' field shall, when the transfer is in the downstream direction, be set to a value, that is incremented for each new transfer, typically a new request. The value assigned shall skip over the '0' value.

- The 'TID' field shall, when the transfer is in the upstream direction, and the message is a response, be set to the value from the corresponding request.

NOTE 1 This makes it possible for the application layer to relate request and responses.

- The 'TID' field shall, when the transfer is in the upstream direction, and the message is an unsolicited response, be set to '0'.

c) The 'Source' field shall be set to a device address of the initiating node.

NOTE 2 A node may be multi-homed and support multiple device addresses. The selection amongst the device addresses of a node is outside the scope of this standard.

d) The 'Destination' field shall be set to a device address of the end node to receive the data.

e) The 'TTL' field shall be set to the total number of hops on the route between the end nodes.

f) The 'SNR' field shall, if the transmission is in the downstream direction be set to '255'. The 'SNR' field shall, if the transmission is in the upstream direction, be set to the SNR of the corresponding request. The 'SNR' field shall, if the information is an unsolicited response, be set to '255'.

g) The 'Nodes' field shall be set to the number intermediate nodes in the route, excluding the end nodes.

NOTE 3 This value is equal to 'number of hops' -1.

h) The 'Current' field shall, if the transfer is in the downstream direction, be set to '1' by the initiating node. The 'Current' field shall, if the transfer is in the upstream direction, be set to 'Nodes' by the initiating node.

i) The 'Address list' shall contain a list of the abbreviated addresses of the intermediate nodes in the route. The order of the elements shall be the order of the nodes when routing in the downstream direction.

NOTE 4 The list is, if a response is to be generated, available from the foregoing request.

j) The Network layer shall transfer a device address of the node to the Link Layer as the SA-field

k) The DA-field of the Link Layer shall be set to 'Source' if 'Current' = '0'. The DA-field of the Link Layer shall be set to 'Destination Address' if 'Current' = 'Nodes +1'. Otherwise the Network layer shall use 'Current' as a pointer to the ‘Address list’. The Link Layer DA-field shall be set to the element pointed to in the ‘Address list’ and converted to a short form address.

8.5.4.3 Rules for receiving routed frames

The Network Layer shall process routed packets received from the Link Layer in the following way;

a) If an error condition is received from the Link Layer then this information shall be passed on to the Application Layer.

b) If the ‘TTL’ field is ‘0’ then an error condition shall be generated and passed on to the Application Layer, else the ‘TTL’ field shall be decremented by ‘1’.

c) If the end of the route has been reached and the ‘Destination’ field is equal to a device address of the node then

   — the Application data shall be passed to the Application Layer and

   — If the message is a request (Network Control bit 6 is ‘1’) then the ‘TID’ and 'Source Address', 'SNR', 'Nodes' and ‘Address List’ shall be stored for later use.

   — No further processing of this packet shall be performed in the Network Layer.

NOTE End of route may be detected in one of the following ways;

i) 'TTL = 0'

ii) Transmission is in the downstream direction and 'Current = Nodes +1'

iii) Transmission is in the upward direction and 'Current = 0'

d) If the end of the route has been reached and the 'Destination' field is not equal to a device address, then an error condition shall be generated and passed on to the Application Layer.

e) If the end of the route has not been reached then the processing shall be continued with the rules for intermediate nodes.

8.5.4.4 Rules for receiving direct connection frames

Alarm and Error conditions or the installation process may generate frames with the direct bit set in the FC field. Such frames shall be processed in one of the following two ways, depending on the Route Request bit.

a) If Route Request = '1'

   If a route to an upstream end node exists, the node shall forward the frame upstream as a routed frame. If the destination address of the frame is multicast or broadcast, the frame shall be forwarded after a random delay, in the range of 0 s-15 s, to minimize the risk of collisions between different nodes forwarding the frame at the same time.

b) If Route Request ='0'

The node may, if the frame is the reporting of an Alarm or Error and a route to and upstream end node exists, send the data as routed frame. The Application Layer data of this frame shall be the full 'direct' Application Data as the data information.

The frame shall be discarded if no route exists or if the routing fails.

The node shall, if it is a search frame, handle the frame as specified in 8.6.5.3

NOTE Direct connection is used for unsolicited responses and generation of the known nodes list. Unsolicited responses can be Alarm or Error reporting, see 8.6.3 and 8.6.4.

8.5.4.5 Rules for intermediate nodes

The Network Layer of an intermediate node shall, in addition to the rules for receiving nodes, process data from the Link Layer in the following way;

a) It shall process the SNR as specified in 8.5.2.7.

b) The ‘Current’ field shall, if the data transfer is in the downstream direction, be incremented by ‘1’ and, if the transfer is in the upstream direction, be decremented by ‘1’.

c) The Network Layer shall transfer a device address of the node to the Link Layer as the SA-field.

d) The Network Layer shall, if 'Current' = '0', transfer 'Source' to the Link Layer as the DA-field. The Network Layer shall, if 'Current' = 'Nodes +1', transfer 'Destination' to the Link Layer as the DA-field. Otherwise the Network Layer shall use 'Current' as a pointer to the ‘Address list’. The Link Layer DA-field shall then be set to the element pointed to in the ‘Address list’ and converted to a short form address.

The intermediate nodes shall as well update the Dynamic Delay field as a part of the routing. This is specified in 8.4.2.5.

8.5.4.6 Rules for sending unsolicited responses

The Network Layer of a node that tries to send an unsolicited response shall process the information in the following way.

A node shall, if a specific route for unsolicited responses is stored in the node, use this route and process the information following the rules for an initiating node.

A node should, if no specific route is stored, but a route to an upstream end node from a previous transfer is recorded / available, use this route and process the information following the rules for an initiating node.

A node should, if no route to an upstream end node is available, broadcast or multicast the frame using direct communication with the Direct bit = '1' and the Route Request bit ='1', see 8.4.2.4.

8.5.5 Timing requirements

This subclause specifies timing requirements specific to the Network Layer. The requirements are listed in Table 35.

Table 35 — Network routing timing

Characteristic	Type	Sym	Min	Typ	Max	Unit
Routing delay [a]	t_{RO}				150	ms

[a] Routing delay: After receiving a packet that shall be forwarded, the node shall start forwarding the packet onto the next hop in less than maximum routing delay.

8.6 Mode Q, Application Layer protocol

8.6.1 General

The format of Application Layer data is as specified below. The Application Layer data may contain multiple sets of Application Layer requests / responses. Each set of Application Layer data is TLV encoded. TLV is a standard abbreviation for Tag - Length - Value encoding. The Tag specifies the type of information, the Length field specifies the length of the Value field and the Value field holds the actual information. The format of Application Layer information is specified in Table 36 below.

Table 36 — Application Layer information format

Tag 1	Length 1	Value 1	Tag 2	Length 2	Value 2	Tag n	Length n	Value n
1 byte	1 byte	N bytes	1 byte	1 byte	M bytes	1 byte	1 byte	P bytes

The Tag field specifies the type of application data that follows. It is listed in Table 37 below. This standard does in general not specify all types of applications in the Application Layer. Only some functions related to the management of the network are defined in the following sub clauses. Most of the values have been reserved for compatibility with existing standards in the EN 13757 family. Especially EN 13757-3:2013 Table 1 describes the usage of the so called CI-Field which can be seen as an equivalent to the Tag field described here.

Table 37 — Application Layer, Tag field

Tag value	Designation	Remarks
00_h – $4F_h$	EN 13757-1 Application	Reserved for DLMS based applications
70_h	Error Reporting	Application error from device
71_h	Alarm Reporting	Not allowed as Application Layer data
82_h	Reserved	Reserved for Network management data
83_h	Network Management	For management of the Network Layer

NOTE The availability of transfer of multiple requests in a single frame may cause the response to be larger than supported by the frame size. This will cause an error condition. Handling of such conditions is outside the scope of this standard.

The Error bit in the Network Control Field of the Network Layer header shall be set when an Alarm or an Error type data set is transferred. See 8.5.2.2 for further details.

8.6.2 EN 13757-1 Application Layer

A node supporting an EN 13757-1 Application Layer shall have a tag field of 01_h. The Application Layer data shall be prepended with a Transport sub-layer consisting of CI, STSAP and DTSAP as specified in EN 13757-1:2014, 10.2.3.

The encoding of the Application Layer data shall follow the requirements as specified in EN 13757-1:2014, 10.3.

A node supporting an EN 13757-1 Application layer shall be able to receive Error Reporting, Alarm Reporting and Network Management data prepended with a Transport sub-layer, as specified above. A node supporting an EN 13757-1 Application Layer may send Error Reporting, Alarm Reporting and Network Management data prepended with a Transport sub-layer, as specified above.

8.6.3 Error reporting

8.6.3.1 General

Error reporting is to be used when a node for some reason cannot provide a requested response. This may be an intermediate node as well as an end node.

A routing node shall contain an error reporting service. The node shall use the service to return error status information. Error information returned shall use a Tag field of 70_h. This corresponds to the CI-field for other modes. The first byte of the Value field is a one byte Type.

The Error bit of the Control field in the Network Layer header shall as well be set as stated in 8.5.2.2.

The Type field may have the values as defined in Table 38 below.

Table 38 — Type field, Error status information

Type value	Designation	Remarks
00_h	Unspecified error	Unspecified error or data missing
01_h	No Application	Unimplemented Tag field
02_h – 09_h	Application error	Compatible with EN 13757-3
$0A_h$ - 10_h	-	Reserved
11_h	No function	Function not implemented in Network Management
12_h	Data error	Data to be supplied are not available
13_h	Relaying error	Cannot relay data further
14_h	Access violation	Data access right violation
15_h	Parameter error	Error in the parameters supplied in the request
16_h	Size error	The amount of data requested cannot be handled
17_h - $1F_h$	-	Reserved
20_h	Wrong Encryption key	Decryption fails
21_h	Wrong encryption method	Encryption method not supported
22_h - EF_h	-	Reserved
$F0_h$	-	Dynamic application error[a]
$F1_h$ - FF_h	-	Manufacturer specific error information

[a] The data point is coded as M-Bus-specific data point with a leading DIF/ VIF. The declaration is vendor specific. The dynamic application error is limited to 7 bytes.

8.6.3.2 No application

This error status shall be returned by the Application Layer, if the requested application Tag field is not implemented in the node. The type field shall be followed by a copy of the incorrect Tag field.

8.6.3.3 Application error

This type of error codes may be used if an EN 13757-3 Application Layer is implemented.

8.6.3.4 No function

This error status shall be returned by the Application Layer, if the requested Network Management function, is not implemented in the actual Application Layer. The type field shall be followed by a copy of the not implemented function field.

8.6.3.5 Data error

This error status shall be returned by the Application Layer, if the request is correct, but the data cannot be provided by the Application Layer in the response.

8.6.3.6 Routing error

This error status shall be returned by the Application Layer, if the node cannot forward data downstream to the next node. The format of the data returned shall be as shown in Table 39.

Table 39 — Routing error format

Type	Status	TID	Ctrl	Source	Destin.	TTL	SNR	Nodes	Curr.	Addr. List
13_h	1 byte	1 byte	1 byte	7 bytes	7 bytes	1 byte	1 byte	1 byte	1 byte	m×2 bytes

The data returned shows the frame that cannot be routed. It contains a header followed by the Network Layer header of the data that cannot be routed.

Type 13_h indication routing error

Status Enumerated, showing status of an attempt;

0 no response from node, timeout four times;

1 Node reacts, but with error in answer.

TID, Ctrl, Source, Destin, TTL

Copies of the Network Layer header information in the frame that cannot be routed. See 8.5.2.1 for detailed information on these fields.

SNR If the node supports SNR measurement, then this field shall contain the SNR received by the node while trying to route the frame. The SNR shall be FF_h if the SNR measurement is not supported, or '00_h'if a timeout condition occurred.

Nodes, Curr, Addr.List

Copies of the Network Layer header information, from the frame that cannot be routed. See 8.5.2.1 for detailed information on these fields.

The Network Layer of an Initiating node shall not generate routing error if it cannot send a message, but just return the error status to its own application layer.

8.6.3.7 Access violation

This type of error status shall be returned by the Application Layer, if the request is not allowed to access the data requested. This may be due to an incorrect access code.

8.6.3.8 Parameter error

This error status shall be returned by the Application Layer, if parameters in the request are outside the current valid range.

8.6.3.9 Size error

This error status shall be returned by the Application Layer, if the request is correct, but the total data in the corresponding response cannot be handled inside a single frame.

8.6.4 Alarm reporting

8.6.4.1 General

Alarm reporting is to be used when a node has critical information for the central node that will not be requested. Alarm reporting should be sent as an unsolicited response.

The Error bit of the Network Control field in the Network Layer header shall as well be set as stated in 8.5.2.2.

A routing node should contain an alarm reporting service. The node shall use the service to return persistent alarm conditions. Alarm information returned shall use a Tag field of 71_h. The first byte of the Value field is a one byte Type field. The format of the data shall be as shown in Table 40.

Table 40 — Alarm information data format

Type	Application data
XX_h	Further Alarm information
1 byte	n bytes

The Type field may have the values as defined in Table 41.

Table 41 — Type field, Alarm information

Type value	Designation	Remarks
00_h	General Alarm	The overall status of the node
01_h	Installation	The node is in an uninstalled mode
02_h – 09_h	-	Reserved [a]
$0A_h$ - BF_h	-	Reserved
$C0_h$ - FF_h	Manufacturer specific.	Manufacturer specific type of alarms

[a] This range was previously defined as application error codes. Error Reporting shall be performed using Tag fields (CI-Fields) 70_h, $6E_h$ or $6F_h$ as specified in EN 13757-3.

8.6.4.2 General Alarm

This function shall be used by a node, to signal that an alarm condition has existed for a prolonged time without being serviced. The condition has caused the node to stop its normal function (consumption counting).

The manufacturer shall state the conditions that will cause a node to generate such alarms.

8.6.4.3 Installation

This function shall be used by a node, to signal that it is in installation mode, i.e. not configured. A node may revert to installation mode, if it is, for a prolonged time, not able to communicate with the network.

The procedure to use during installation mode is outside the scope of this standard.

The manufacturer shall state the conditions that will cause a node to revert back to installation mode.

8.6.5 Network Management service

8.6.5.1 General

A routing node shall contain a network management application. Data shall be passed on to the network management application, whenever the Tag field is 83_h. The general format shall be as specified in Table 42. The first byte of the Value field is a one byte Function Type field that defines the way data shall be interpreted.

Table 42 — Network management data format

Type of function	Application data
XX_h	Function specific information
1 byte	x bytes

The functions listed in the table below covers the following generic network management requirements:

— There will be a demand for precision time tagging of information the nodes as there is a drift of the real time clock in the nodes. It shall thus be possible to set the time in the nodes. This time setting shall include corrections for the delay in any intermediate nodes.

— It shall be possible to generate and retrieve a list of the nodes that a routing node is able to receive data from, in order to set up the proper routes / transmission paths.

— It shall be possible to pass on information about failures in the forwarding of information through routing nodes. Two situations exist, failure in the transfer downstream, and failure in the transfer upstream. The purpose of such error messages is to be able to detect failing link in order to maintain an efficient and robust data transfer network.

The Type field may have the values as defined in Table 43 below.

Table 43 — Types of network management functions

Type	Designation	Remarks
01_h	Time sync	Time synchronization signal
13_h	Generate known nodes list	Start generating a list of network nodes known to the node
14_h	Get known nodes list	Submit a list of network nodes known to the node
21_h	Routing status	Request and return of message on any previous failing upstream routing
22_h	Wait	Cannot provide data yet. Try again later
$C0_h$ - FF_h	Manufact.	Manufacturer specific type of functions

Values of Type in the range 00_h to BF_h are for standardized used. Values, in this range, not listed in the table above are reserved for future use (RFU) and shall not be used. Values in the range 80_h to FF_h may be used for manufacturer specific functions.

For the Type of commands listed above the format for the application data following the Type and the corresponding functionality is listed below.

8.6.5.2 Time sync

This function is used when the primary station, the data collection unit, wants to synchronize the time in the nodes it receives data from. The format of the request shall be as specified in Table 44.

NOTE 1 This request may be sent using broadcast or multicast address.

Table 44 — Time sync request format

Type	Year	Month	Day	Hour	Min	Sec	Time Zone	Acc. Ctrl
01_h	1 byte	1 byte	1 byte	1 byte	1 byte	1 byte	1 byte	4 bytes (opt)

Type 01_h indicating time sync

Year: 1 byte, unsigned integer, years since 2000, range 5 ..99

Month: 1 byte, unsigned integer, range 1..12

Day: 1 byte, unsigned integer range, 1..31

Hour: 1 byte, unsigned integer, range 0..23

Min: 1 byte, unsigned integer, range 0..59

Sec 1 byte, unsigned integer, range 0..59

Time Zone: 1 byte signed, range -12 to 12, offset relative to UTC

NOTE 2 This makes it possible to handle time zones and Daylight Saving Time.

Access Ctrl: 4 bytes, optional, shall be present if the node uses access control on this request. The algorithm to use for access control is outside the scope of the current standard.

The initiating node shall ensure that the Time-info bit of the FC-field at the Link Layer is set and shall insert a value into the DLY field at the Link Layer. The value shall correspond to the delay from the time the clock value was read from the clock source and until the sync sequence in the preamble is transmitted.

Any intermediate node shall, to the current value of the DLY-field at the Link Layer add the delay from detecting the sync sequence in the preamble during reception to the transmission of the sync sequence on the next hop.

The format of the response shall as specified in Table 45.

Table 45 — Time sync response format

Type	Offset
01_h	1 byte

Type 01_h indicating Time sync

Offset: 1 byte, time offset. This is the numerical value of offset in seconds between the time from the internal clock in device and the time in the command, taking dynamic delay into account. The signal may be used as an quality indicator of the stability and drift of the clock on the device. The offset shall be set to 255 if the actual offset is larger than 255.

The manufacturer shall state the precision of the delay calculation in initiating as well as in intermediate nodes.

8.6.5.3 Generate known nodes list

This is the Network Management request to use, to activate a search for neighbour nodes that can be heard.

The format of the request shall be as specified in Table 46.

Table 46 — Generate known nodes list request format

Type	SNR-list	Stop cond.	Access Control
13_h	5 bytes	1 byte	4 bytes (optional)

Type 13_h indicating Generate known nodes list

SNR-list: 5 bytes, Signal to Noise Ratio list, a list 5 of thresholds values to use in the search. Each value is a detection threshold for the Signal to Noise Ratio. The threshold values shall be listed in descending order. If less than 5 thresholds are used, then the non-used values shall be '0'.

Stop. cond. 1 byte, Stop Condition, number of times the last search for nodes shall performed, without getting a response from a node, range 1 to 6.

Access Ctrl: 4 bytes, optional, shall be present if the node uses access control on this request. The algorithm to use for access control is outside the scope of the current standard.

The way to react to this command is specified in 8.4.4.

The format of the response shall be as specified in Table 47.

Table 47 — Generate known nodes, response format

Type	Num. nodes
13_h	1 byte

Type 13_h indicating Generate known nodes

Num.nodes: 1 byte, number of nodes detected during the search.

The algorithm to use to generate the SNR-list is outside the scope of the current standard.

8.6.5.4 Get known nodes list

This is the Network Management request to use to retrieve a list of known nodes from a specific node. The format of the request as well as the response shall be as listed below.

The format of the request shall be as specified in Table 48.

Table 48 — Get known nodes list, request format

Type	Pointer
14_h	1 byte

Type 14_h indicating Get known nodes list

Pointer: 1 byte, indicating where to read data from. A value of '1' shall be used to get data from the start of the list.

The format of the response shall be as specified in Table 49.

Table 49 — Get known nodes list, response format

Type	**Pointer**	**Node Info1**	**...**	**Node Info n**
14_h	1 byte	8 bytes		8 bytes

Pointer: 1 byte, indicating where to read next block of data from. A value of '0' shall be returned when all data has been read. Using the pointer returned as parameter in the next request shall return the subsequent block of data. The algorithm used to generate this pointer is outside the scope of this standard.

Node Info: 8 bytes with the following content.

Address: 7 bytes, a device address of the node, i.e. the source address detected at the Link Layer level.

SNR: 1 byte, range 0..255. The Signal to Noise Ratio in dB measured during the most the most recent node search sequence.

8.6.5.5 Routing status

An error while transferring data upstream is at the same time a fault in the transmission path for information. This inhibits the transfer of information to the central node. If this condition occurs, then the router should store the error status locally and await restoration of the transmission path.

Upstream data transfer is normally the response to a request. The central node will detect the missing response and shall retry the request. The central node shall if this fails try to establish an alternate transmission path to this node.

A routing node may, if the error condition remains for a prolonged time, switch back to installation mode. See 8.6.4.3 for further details.

NOTE 1 The mechanism for storing the error status locally and for establishing alternate transmission paths is outside the scope of this standard.

Once the transmission path has been re-established the information about the error condition may be retrieved by the central node. The format of a routing error status, the request as well as the response is listed below:

If implemented, the format of a routing error status request shall be as specified in Table 50.

Table 50 — Routing status request format

Type	Modifier
21_h	1 byte

Type:	21_h	Indicating Routing status
Modifier:	1 byte,	with bit fields.
	Bit 7	0 = return first block from list
		1 = return subsequent block from list
	Bit 6..0	'0', reserved for future use

This error status should be available from the Application Layer, if the node cannot forward data upstream to the next node. The format of the data returned shall be as given in Table 51. One set of error information shall be returned for each request.

Table 51 — Routing error format

Type	Status	NCtrl	TID	Destin.	Source	TTL	SNR	Nodes	Curr.	Addr. List
21_h	1 byte	1 byte	1 byte	7 bytes	7 bytes	1 byte	1 byte	1 byte	1 byte	m×2 bytes

The data returned shows the frame that cannot be routed. It contains a header followed by the Network Layer header of the data that cannot be routed.

Type 21_h indication routing status

Status 1 byte, Enumerated, showing status of attempt;

0 no response from node, timeout three times;

1 Node reacts, but with error in answer

2 No pending errors.

TID, Ctrl, Source, Destin, TTL, SNR, Nodes, Curr, Addr.List

Copy of the Network Layer header information in the frame that cannot be routed. See 8.5.2 for detailed information on these fields.

A Status of 02_h and no further data shall be returned if no error condition information has been recorded.

NOTE 2 The number and structure of error data stored in the node for later retrieval is outside the scope of this standard.

8.6.5.6 Wait extension

Certain requests at the Application Layer may have a long response time. This could cause timeout at the Application Layer with following retransmissions. To limit the number of timeout conditions, the Wait extension response has been introduced. A node that has received a request may return a Wait extension response. This indicates that the node is not able to respond yet and that the request will be returned at a later time. A Wait extension response shall only be sent from an end node. The format of the response shall be as specified in Table 52.

Table 52 — Wait extension response format

F-field
22_h

F-field 22_h indicating the wait extension request.

The Wait extension response shall be sent with a TID of '0'. The node sending the Wait extension response shall reply with the actual response without further requests. This response shall use the original 'TID'.

The manufacturer shall, for nodes implementing Wait Extension, state the maximum response time after a Wait extension.

8.6.6 Timing requirements

The timing requirements that shall apply at the Application Layer level is given in Table 53 below.

Table 53 — Application Layer timing

Characteristic	Symbol	Min	Typ	Max	Unit
Response delay [a]	t_{RD}	20		10 000	ms
Response wait [b]	t_{RW}			21 000	ms

[a] Response delay: After receiving a request, the node shall not start sending the response back in less than the minimum response delay and shall start sending the response back in less than the maximum response delay.

[b] Response wait: After sending a request and expecting a response, a node shall, at the Application Layer, not time out the connection in less than the maximum response wait time. The maximum value takes into account that some of the nodes needs wake up signal. The maximum value may be extended, after agreement with the operator.

8.6.7 COSEM extension

8.6.7.1 Introduction

It has been recognized that there is a need for some new dedicated Interface Classes when new lower layer and new functionalities are added.

8.6.7.2 Mode Q Channel, interface class

Instances of this interface class, see Table 54, define the operational parameters for communication using the mode Q interface.

Table 54 — Mode Q, Interface Class specification

Mode Q Channel		**0..*n***	**class_id=71, version = 1**		
Attribute(s)		***Data Type***	***Min.***	***Max.***	***Def.***
1. logical_name	(static)	octet-string			
2. addr_state	(static)	enum			
3. device_address	(static)	octet-string			
4. address_mask	(static)	octet-string			
Specific Method(s)		***m/o***			

Attribute description

addr_state	Defines whether or not the device has been assigned an address since last power up of the device enum (0) Not assigned an address yet (1) Assigned an address either by manual setting, or by automated method.
bus_address	The currently assigned address of the device on the network octet-string.
address_mask	The group address the device will respond to, when short form addressing is used. octet-string

8.6.7.3 Mode Q Setup

This COSEM object defines and controls the behaviour of the device regarding the communications parameters according to mode Q of this European standard. It is an instance of the interface class "Mode Q Channel" as given in Table 55 below.

Table 55 — Mode Q Setup

Mode Q Setup	OBIS identification						
	IC	A	B	C	D	E	F
Mode Q Channel Object	Mode Q channel	0	X	31	0	0	0xFF

The usage of value Group B shall be:

— if more than one object of the type is instantiated in the same physical device its value group B shall number the communications channel.

NOTE A node having more than one network address, i.e. a multi-homed node will have multiple objects of this type.

9 Single-hop repeaters

9.1 General

9.1.1 Ways of operating

A repeater may work as a Unidirectional Single Hop Repeater (USHR) or as a Bidirectional Single Hop Repeater (BSHR). The selection of the way the repeater works depends on;

— Is the repeater to be battery operated?

— Is the repeater going to send messages to the Meter?

A battery operated repeater requires registration of specific meters to limit the number of devices it is repeating for. Meter access (bidirectional communication) requires a unique meter assignment to the repeater initially to avoid collisions. Both the meter registration and the meter assignment require a Network Control and increased resources for installation and maintenance. Therefore three possible ways a repeater can perform are defined. These three different possibilities are described in the following clauses.

9.1.2 Unregistered repetition

In this situation the meters are not configured to the repeater. There is no meter registration. The repeater simply repeats all meter frames it receives. Since this will require that the receiver of the repeater is continuously open for reception, this kind of repetition is not suitable for battery operated repeaters. This kind of repetition can only be used upstream (from meter to Other Device), frames from both uni- as well as bi-directional meters can be repeated.

The repetition shall be randomly delayed with T_{DRR}. Because of this randomized delay, several repeaters can operate in the same area and handle the same meters with a minimum risk of collision on the radio channel.

The Repeater shall only repeat frames which are received with a cleared Hop Count-bit. In the repeated frames the Hop Count-bit shall be set, but this kind of repetition shall never set the Repeated Access-bit. The Hop Count-bit and the Repeated Access-bit are described in 9.6.2 and 9.6.3.

The Unregistered Repetition may be performed by USHR as well as BSHR.

9.1.3 Registered repetition

In this situation the meters are configured (meter registration) to the Repeater Meter List (RML). Since the meters to be handled are now known to the repeater, the repeater has the ability to switch on its receiver only when the meter transmits its synchronized frames, and therefore this kind of repetition is suitable for battery operated repeaters. This kind of repetition can only handle uni-directional communication in the direction from Meter to Other Device, but both uni-directional and bi-directional meter frames can be repeated.

The repetition shall either be randomly delayed with t_{DRR}, or it shall use one of the mode dependant optional timeslots ($t_{DRSlotN}$). If the repeater chooses to use one of the optional timeslots, it shall randomly select a new timeslot from frame to frame. Because of this randomized delay, several repeaters can handle the same meters with a minimum risk of collision on the radio channel.

The Repeater shall only repeat frames which are received with a cleared Hop Count-bit. In the repeated frames the Hop Count-bit shall be set, but this kind of repetition shall never set the Repeated Access-bit. The Hop Count-bit and the Repeated Access-bit are described in 9.6.2 and 9.6.3.

The Registered Repetition may be used by USHR as well as BSHR.

9.1.4 Assigned repetition

In this situation the meters are, like for registered repetition, configured to the Repeater Meter List (RML), but furthermore the meter is uniquely assigned to this repeater (Meter assignment marked by the Assignment bit in the RML). Since the meter is only assigned to one single repeater, this repeater is allowed to repeat the frames from the meter with a fixed delay and thereby enabling the possibility of establishing a bi-directional communication session with the meter via this repeater. Since the meters to be handled is now known to the repeater, the repeater has the ability to switch on its receiver only when the meter transmits its synchronized frames, and therefore this kind of repetition is suitable for battery operated repeaters.

The repetition shall be delayed with a fixed delay (t_{DRFS}; t_{DRFE}). Since this kind of repetition uses a fixed delay without any randomization, the unit assigning meters to repeaters (a network controller, fixed data collector or hand held terminal etc.) shall ensure that the actual meter is not already assigned to another repeater. In case of assigning the same meter to several repeaters, this will result in recurring collisions on the radio channel.

The Repeater shall only repeat frames which are received with a cleared Hop Count-bit. In the repeated frames the Hop Count-bit shall be set. Furthermore this kind of repetition shall set the Repeated Access-bit to indicate that the repetition is fixed in time and that a bi-directional communication session can be established to bi-directional meters via this repeater. Explanations on the Hop Count-bit and the Repeated Access-bit are described in 9.6.2 and 9.6.3. The Other Device shall check the B, A, H and R bits before accessing the meter.

The Assigned Repetition can be used by either a BSHR or a USHR, giving a fixed delay in the repetition of the meter transmission, but noting that the USHR cannot support access to the meter.

Note, that an assignment can be applied both for uni- and bidirectional meters. Therefore the Accessibility bit (Bit A) and the Repeat Access bit (Bit R) should be checked before the Other Device tries to access a Meter via a Repeater.

9.2 Physical Layer protocol and data encoding

This Single Hop Repeater protocol supports the Physical layers as specified for Mode S, T, C, N and F in EN 13757-4. Data shall, for the supported modes, be encoded as specified in EN 13757-4.

A Single Hop Repeater may support one or more Physical Layers. The Single Hop Repeater shall by default repeat the message using the same mode and channel as it is receiving on. It may repeat the message in a different mode or channel, as set by manufacturer specific configuration.

NOTE Patents may prevent the conversion between VHF and UHF band.

The Single Hop Repeater shall, for Management purpose, be accessible as a device in the same modes and channels as it is repeating. If the repeater supports several radio modes in parallel, it shall also provide management service access on each enabled radio mode.

9.3 Media Access duty cycle

The Single Hop Repeater shall itself ensure that its transmission is within the duty-cycle and off-time limits as specified in CEPT REC 70-03. It may skip repeating messages, like only repeating every N'th message, in order to meet these requirements. The Supplier of the Repeater shall state how this limitation is achieved.

9.4 Timing

9.4.1 General

The usage of a Repeater leads to an additional delay of the transmitted radio frame in the upstream and downstream direction. This is named uplink and downlink delay.

As described in the previous clauses, there are several possible ways of repeating, leading to three different timing schemes:

— Unregistered repetition shall use the randomly delayed repetition.

— Registered repetition shall use either the randomly delayed repetition or alternatively the optional timeslots.

— Assigned repetition shall always use default time slot.

These timing schemes are described in the following clauses.

9.4.2 Uplink delay – default time slot

Assigned repetition is the only kind of repetition that uses the fixed delay of the default time slot. The default time slot is mode dependent. It is given in Table 56 below.

Table 56 — Uplink delay for Assigned Repeating (slot 0)

Mode	Symbol	Min	Typ.	Max	Unit
S [a]	t_{DRFS}	375		975	ms
T [a]	t_{DRFS}	375		975	ms
C [b]	t_{DRFE}	0		5	ms
N [b]	t_{DRFE}	0		5	ms
F [b]	t_{DRFE}	0		5	ms

a The delay of the repeater retransmission is referred to the start time of the meter transmission

b The delay of the repeater retransmission is referred to the end time of the meter transmission

NOTE The fixed uplink delay corresponds to time slot 0.

9.4.3 Uplink delay – optional timeslot

Registered repetition is the only kind of repetition that uses the optional time slots. The optional time slots are mode dependent. The use of optional time slots is only applicable to Modes S, T and C. The optional time slots are given in Table 57 below.

Table 57 — Uplink delay - optional timeslots

Mode	Slot 1	Slot 2	Slot 3	Slot 4	Slot 5	Slot 6	Slot 7	Unit
Symbol	$t_{DRSlot1}$	$t_{DRSlot2}$	$t_{DRSlot3}$	$t_{DRSlot4}$	$t_{DRSlot5}$	$t_{DRSlot6}$	$t_{DRSlot7}$	-
S [b]	1460	[a]	[a]	1640	[a]	[a]	1820	ms
T [b]	1460	1520	1580	1640	1700	1760	1820	ms
C [c]	30	55	80	105	130	155	180	ms

a This combination of time slot and mode is not used

b The delay of the repeater retransmission is referred to the start time of the meter transmission

c The delay of the repeater retransmission is referred to the end time of the meter transmission

It is recommended to use Listen Before Talk (LBT) if these optional time slots are used for the retransmission.

NOTE A timing diagram showing the use of these additional time slots is found in Annex A, Figure A.4.

9.4.4 Uplink delay - randomly delayed repetition

Both registered repetition and unregistered repetition, but not assigned repetitions, uses the randomly delayed repetition. In this situation the repetition shall be delayed by t_{DRR}. The interval between $t_{DRR(min)}$ and $t_{DRR(max)}$ is not divided into timeslots and the start of transmission can be chosen freely within this interval. To avoid collisions with other repeaters, the repeater should delay the retransmission randomly homogeneously distributed over the entire interval. The interval is given in Table 58 below.

Table 58 — Uplink delay - random time delay of the repeater

Mode	Symbol	Min	Typ.	Max	Unit
All	t_{DRR}	5000		25000	ms

NOTE It is, due to this unknown delay, not possible to calculate accurately the actual consumption (power, flow) based on the difference of the index values of subsequent messages.

9.4.5 Downlink delay and FAC-Transmission delay

The BSHR shall transmit downlink data to the Meter when the access window of the Meter is open. The BSHR downlink delay can thus not be calculated based on the time of reception of the downlink data from the Other Device. The BSHR downlink transmission window shall instead be calculated based on the timing of the data previously received by the repeater from the Meter in the uplink direction. The delay is defined by t_{RO} or t_{RO_slow}.

For mode C and mode N(using slow access window), the Other Device is initiating the data exchange after receiving the periodical Meter transmission. It is possible for the repeater to retransmit in the time window between the Meter transmission and the meter access window. This includes upstream retransmission of the frame from the Meter to the Other Device as well downstream retransmission of the frame from the Other Device to the Meter. The repeated response is thus returned in the immediately succeeding access window.

For Mode S, T and F, the Other Device has to initiate the data exchange before the periodical Meter transmission. The repeater receives the frame and 'holds' it. The repeater is transmitting the frame 'on hold' from the Other Device downstream to the Meter in its listening window, after the periodical Meter transmission. The response from the Meter is delayed by t_{RM} or $t_{TxD.}$ The first meter message is retransmitted upstream to the Other Device in the meantime. The Other device may respond immediately. This response is again stored "on hold" by the repeater until next meter transmission. The retransmission downstream happens in the next listening window of the Meter. See EN 13757-4 for specific information of meter response time and the Frequent Access Cycle of the Meter.

9.4.6 Installation announcement delay

After the reception of a SND-IR, C=46$_{h,}$ the Repeater is delaying the repetition by t_{DRR}, see 9.4.4 Thereafter it shall generate an additional SND-NKE message, using the same mode and channel as the repeated message. This shall occur after a delay of t_{IA}, see Table 59 for values. This message confirms the ability of this repeater to receive this Meter.

Table 59 — Installation announcement delay

Characteristic	Symbol	Min	Typ.	Max	Unit
Installation announcement delay	t_{IA}	5		5000	ms

9.4.7 Other Device response delay

When the Other Device receives a repeated message and intends to access the Meter (Hop Count-bit and Repeat Access-bit are set), the Other Device's response delay is dependent on mode and optionally fast or slow response delay (D-field).

For Mode C, the response delays t_{RR} and t_{RR_slow} shall be 85 ms shorter than the response delay t_{RO} and t_{RO_slow} used for direct access, see EN 13757-4.

For Mode N, the response delays t_{RR} and t_{RR_slow} shall both be the same as the response delay t_{RO} used for direct access, see EN 13757-4:2013.

For all other modes, the response delay shall be as for direct access.

9.5 Data Link Layer protocol

9.5.1 General

The Data Link Layer shall be as specified in EN 13757-4. Both frame Format A and frame Format B shall be supported as defined by the mode. The Repeater shall repeat the frame with the same format it was received.

NOTE The repeater has to change one or two bits in the frame. That's why the CRC of the affected block has to be recalculated before the retransmission.

9.5.2 C-Field

Unregistered repetition shall only repeat frames with C-Fields of C=46$_h$ or C=44$_h$. All other frames, including ACC-NR, C=47$_h$, shall be ignored.

Registered repetition shall only repeat frames with C-Fields C=46$_h$ or C=44$_h$ or C=48$_h$. The ACC-NR (C=47$_h$) frame may be used for synchronization but it should not be repeated. For large transmission intervals like N-mode (one transmission a day) an ACC-NR frame may also be repeated as a stay-alive message. All other frames shall be ignored.

Assigned repetition shall repeat all types of frames with any C-Field to/from all meters that are assigned to the repeater.

NOTE The repeater has to limit its transmission within the allowed duty cycle. Therefore repeating of particular messages may be skipped (see 9.3).

The repeater shall, if it receives an installation frame (SND-IR, C=46_h) with a Hop Count-bit = 0, generate a SND-NKE. With this frame the ability of receiving this meter is confirmed by the repeater to an optional installation service tool. The frame shall be generated after a delay of t_{IA} after retransmission of the meter frame itself. The installation procedure with repeater is shown in Annex A.

The C-Field of the frames sent to the repeater itself (for management purpose) shall follow the rules of EN 13757-4. All commands send to a repeater shall be transmitted as a SND-UD or SND-UD2 message. The repeater shall reply to this SND-UD or SND-UD2 message as specified in EN 13757-4.

If a response is to be read from the repeater itself, a message of the type REQ-UD2 or SND-UD2 shall be transmitted to the repeater. The repeater shall respond with a RSP-UD message containing the relevant response.

9.5.3 Address

The address of a Single Hop Repeater shall be as defined in EN 13757-4:2013, 11.5.6. It shall consist of the Manufacturer ID (M-field) and Address (A-field consisting of Identification number, Version number and Device type information). The Address elements are described in EN 13757-3:2013, 5.5 to 5.8.

A repeater may be a dedicated device or functionally integrated into a Meter or any other device. An integrated repeater shall, except for Device Type, use the Manufacturer ID, Identification number and Version of the hosting Meter or Other Device. Both integrated and dedicated repeaters shall always apply one of the "Repeater" Device types, when transmitting self generated messages, e.g. management data, see 9.7.4.

A Single Hop Repeater, not able to accept meter assignments, i.e. only supporting USHR and not able to access bidirectional meters, shall use Device Type 32_h (unidirectional). A Single Hop Repeater with full functionality (BSHR) shall use Device Type 33_h (bidirectional).

9.6 Transport Layer and Extended Link Layer protocol

9.6.1 General

To ensure that a receiver can identify that a frame has been repeated and whether or not the repeated frame can be used to establish a bidirectional communication session with the meter, this information have to be indicated in the frame itself.

This information is implemented using two bits in the Communications Control Field, a Hop Count-bit (H-field) and a Repeated Access-bit (R-field). The repeater retransmits only frames which supports these two bits.

9.6.2 Hop Count, (H-field)

The Hop Count-bit (H-field) indicates that the frame has been repeated, i.e. the hop counter has been incremented. A frame transmitted by the Meter shall have H = 0. A Single Hop Repeater shall set H =1 in the repeated frame. This shall be the case when repeating upstream as well as downstream. A frame transmitted by the Other Device shall set H = 0 and the Single Hop Repeater shall set H = 1 in the repeated frame. Single Hop Repeaters shall only repeat frames where the H = 0.

The bit identifies whether the frame received is the original frame from the Meter / Other Device or a frame sent via a Single Hop Repeater. This mechanism ensures that repeated frames are not further repeated by other Single Hop Repeaters leading to uncontrolled repetition of the same frame.

9.6.3 Repeated Access (R-field)

Single Hop Repeating can be performed in three ways; unregistered repetition, registered repetition and assigned repetition. See 9.1.1 to 9.1.4 for further explanation on these repetition modes.

This leads to the requirement of informing the receiver, i.e. the Other Device, about the repetition mode. This is implemented by introducing the Repeated Access-field. Only repeaters having the meter uniquely assigned to it shall utilize this bit, informing the receiver that the frame has been repeated with a fixed delay. In the case of a bi-directional Meter transmission it allows the Other Device to establish a bi-directional communication session with the Meter via the repeater.

If the Other Device wants to use the repeater in the establishment of a bi-directional communication session with the Meter, the R-field shall be set, i.e. R=1 in the frame transmitted by Other Device. This indicates to the repeater, that the Other Device wants to make use of it downstream. If this bit is cleared in the frame transmitted from Other Device, a direct bi-directional communication session between the Other Device and the Meter is established without the use of a repeater. When the repeater repeats the frame downstream it shall clear the R-field, i.e. R =0, thereby indicating that this frame is now to be received by the Meter.

This leads to the following rules for the Repeated Access-field;

— Upstream;

  — Meter to Single Hop Repeater, R = 0 in the frame

  — Single Hop Repeater to Other Device;
    R = 1 if the frame is repeated by an assigned repeater with a fixed delay,
    R = 0 if the frame has been repeated by a not assigned repeater with a random delay or with optional timeslots.

— Downstream;

  — Other Device to Single Hop Repeater:
    R = 1 if the Other Device wants to use the Single Hop Repeater for this frame,
    R = 0 if the Other Device is communicating directly with the Meter.

  — Single Hop Repeater to Meter: R = 0 in the frame.

9.6.4 Transfer of H- and R-fields within a frame

The Repeater shall only retransmit frames with a Transport Layer (short or long data header) or an Extended Link Layer. The following paragraphs show the position of the two fields within all types of frames.

Retransmission by the Transport Layer:

The two fields defined above are transmitted in the Configuration Word of the Transport Layer (Short Transport layer or Long Transport Layer) as defined in EN 13757-3 or in the Transport Layer as defined in EN 13757-4. The H-field and the R-field are not supported for all encryption modes. The repeater shall only repeat messages where the encryption mode supports the two fields. Messages not supporting the two fields shall be ignored.

NOTE At the time of release of this standard only the encryption modes 0 and 5 support the retransmission by a repeater. Please check the latest version of EN 13757-3 for all supported encryption modes.

The position of the two bits in the Configuration Word, as defined in EN 13757-3 for encryption Mode 5, is shown shaded in Table 60 below.

Table 60 — Configuration Word

Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Bi-directional communication	Accessibility	Synchronized	Reserved	Mode bit 3	Mode bit 2	Mode bit 1	Mode bit 0	Number of encr. Blocks	Number of encr. blocks	Number of encr.	Number of encr. blocks	Content of frame	Content of frame	Repeated Access	Hop Count
B	A	S	0	M	M	M	M	N	N	N	N	C	C	R	H

Retransmission by the Extended Link Layer:

The H- and R- fields defined above are transmitted inside the Communication Control Field as defined in EN 13757-4. The position of two field bits, handled by the repeater is shaded in Table 61 below.

Table 61 — Communication Control Field

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Bi-directional subfield	Response Delay subfield	Synchronized subfield	Hop Count subfield	Priority subfield	Accessibility subfield	Repeated Access subfield	Reserved for future use (RFU)
B	D	S	H	P	A	R	0

The repeater is only allowed to change the value of the two bits marked in the tables above. All other bits are managed by the Meter and shall not be changed by the repeater.

If a frame contains an Extended Link Layer as well as a Transport Layer then the Hop Count-bit and Repeated Access-bit in the Transport layer shall be ignored.

9.7 Application Layer Protocol

9.7.1 General

An assigned or registered repeater shall have a Management Application in the Application Layer. Access to the different application is determined by the values of the CI-field.

9.7.2 Common functions

It should be possible to use a common management system for Meters and Repeaters. A repeater shall therefore conform to general rules like every Meter. A repeater shall provide status information just like all Meters. The repeater shall send this data periodically. The repeater shall send this information using its own address. The repeater should optionally send installation messages (SND-IR, C=46_h) fulfilling the requirements and the timing as specified in EN 13757-4.

The Repeater shall support the Status byte to report internal errors conformant to EN 13757-3:2013, 5.10 if the Status byte is present in the frame. Additional information may be requested from a Repeater using Get Repeater Status function (F-field = 33_h).

9.7.3 CI field

The CI-fields defines the services accessed in the upper layers. The CI-field for the different services in the management application in a repeater is specified in Table 62 below.

Table 62 — CI-field

CI-field	Designation	Remarks
$6E_h$ - 70_h	Error Reporting Service	See 9.8.1
80_h	Transport Layer (used for REQ-UD2)	Request to device
83_h	Network Management Application	Command to device
89_h	Network Management Application	Response from device
$8A_h$	Transport Layer (used for ACK)	Acknowledge from device

In addition to the above listed CI-fields, general data elements and manufacturer specific CI-fields may be used. See EN 13757-3 for such values.

9.7.4 Repeater management data elements

9.7.4.1 Repeat Meter List (RML)

9.7.4.1.1 Structure of RML

The Repeat Meter List is a table of registered meters with additional information about the link and meter. There is one row for each Meter. The RML is used for Registered Repetition and Assigned Repetition only. In these modes the Repeater receives and transmits meter-frames only from meters which are registered in the RML. The structure of the RML is shown in Table 63 below. The RML has 16 columns with different information size. The first 8 columns are fixed. The last 8 columns are reserved for manufacturer specific data. The content of the allocated columns is specified in the following.

Table 63 — RML structure

Column	1	2	3	4	5	6	7	8	9	...	16
Description	Address (ADD) [a]	Radio-Mode (RMD) [a]	TX-Interval (TXI) [a]	RX Time (RXT) [a]	RSSI-Level (LVL)	Status (STS)	RFU [b]	RFU [b]	Manuf.spec. 1	...	Manuf.spec.8
Size [bytes]	8	3	2	3	1	1					
Line 1	ADD 1	RMD 1	TXI 1	RXT 1	LVL 1	STS 1	-	-			
Line 2	ADD 2	RMD 2	TXI 2	RXT 2	LVL 2	STS 2	-	-			
Line n	ADD n	RMD n	TXI n	RXT n	LVL n	STS n	-	-			

a The content of multi byte fields are stored with least significant byte first.

b RFU: Reserved for future use. Shall by default be "0"

9.7.4.1.2 Address:

This column holds the Data Link Layer address of the registered or assigned Meter. The format of the address is given in EN 13757-4:2013, 11.5 (Manufacturer, Identification number, Version, Device type).

9.7.4.1.3 Radio-Mode:

This column holds the allowed radio modes for the frame from the meter. The different modes are defined in EN 13757-4:2013. The format of the column is defined in 9.9.2.2.

9.7.4.1.4 TX-Interval:

The TX-Interval contains the transmission period of the meter. The value shall be coded as specified in 9.9.2.3. A value of 0h shall be used as default or if no TX-Interval is available. See as well 9.9.3.

9.7.4.1.5 RX Time:

The RX Time is the time since last reception of a message from the meter. The value shall be coded as specified in 9.9.2.2. A value of 0_h is used as default. The value shall be FF FF FF_h, if the maximum value of the transmission period value has been exceeded.

9.7.4.1.6 RSSI-Level:

The RSSI level contains the received signal strength indication of the latest frame received. The coding of the RSSI level shall be according to EN 13757-3:2013, Table 9.

9.7.4.1.7 Status:

9.7.4.1.7.1 Structure:

The Status (STS) is bit mapped, as shown in Table 64 below. It contains actual information about the link. The interpretation of the different fields follows below the table.

Table 64 — Status

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
Assigned	Hit rate			RFU [a]	RFU [a]	Link state	
[a] Reserved for future use. Shall be returned as 0.							

9.7.4.1.7.2 Link state:

Link state is a two bit field, as shown in Table 65. It gives information about the actual state of the link between the Meter and the Repeater, as seen from the repeater.

Table 65 — Link state

bit 1	bit 0	Explanation
0	0	Default (device has never been received)
0	1	Link in normal operation
1	0	Link temporarily interrupted
1	1	Link permanently interrupted

A repeater may, if it has lost the synchronization with a meter; automatically try to re-establish the link performing one or more radio scans. The repeater shall mark its state as temporarily interrupted as long as it tries to resynchronize. It shall change its state to permanently interrupted when the attempt is over. The number of retries to perform is manufacturer specific. The repeater shall change its state to normal operation if the link is re-established.

9.7.4.1.7.3 Hit rate:

The Hit rate, as shown in Table 66, is to get an overview of the last frames received. The generation of the hit rate is manufacturer specific. The period for hit rate calculation should be less than 40 days.

Table 66 — Hit rate

bit 6	bit 5	bit 4	Reception hit rate
0	0	0	0% - <5% (default value)
0	0	1	5% - < 45%
0	1	0	45% - < 75%
0	1	1	75% - < 90%
1	0	0	90% - < 95%
1	0	1	95% - < 98%
1	1	0	98% - < 100%
1	1	1	100%

9.7.4.1.7.4 Assigned bit:

The assigned bit is set to 1 if a meter is exclusively assigned to this repeater (Meter assignment), otherwise it shall be set to 0 (default).

9.7.4.2 Radio Scan List (RSL)

The Radio Scan List includes addresses as well as some additional information for all meters the Repeater has received radio frames from since last flush of the RSL. The structure of the list is identical to that of the Repeat Meter List, except that Column 6, status is a reserved element. See Table 67 below.

Table 67 — Radio Scan List

Column	1	2	3	4	5	6	7	8	9	...	16
Description	Address (ADD) [a]	Radio-Mode (RMD) [a]	TX-Interval (TXI) [a]	RX Time (RXT) [a]	RSSI-Level (LVL)	RFU [b]	RFU [b]	RFU [b]	Manuf.spec. 1 [c]	...	Manuf.spec. 8
Size [bytes]	8	3	2	3	1						
Line 1	ADD 1	RMD 1	TXI 1	RXT 1	LVL 1						
Line 2	ADD 2	RMD 2	TXI 2	RXT 2	LVL 2						
Line n	ADD n	RMD n	TXI n	RXT n	LVL n						

a The content of multi byte fields are stored with least significant byte first.

b RFU: Reserved for future use. Shall by default be "0".

c The columns 9 through 16 are allocated to Manufacturer specific information.

9.8 Error Reporting Services

9.8.1 General

The Repeater shall support an Error Reporting Service. The Repeater shall use the service to return error status information. Error reporting is used in the response to command that fails. Error information returned shall use a CI-field of 70_h or $6E_h$. The first byte following the CI-field is a type field. The format of the data shall, dependent of the value of the CI field, be as shown in Table 68 or in Table 69.

Table 68 — Error status (no header)

CI	Error type	Application data
70_h	XX_h	Further error information
1 byte	1 byte	n bytes

Table 69 — Error status (short header)

CI	Access no.	Status	Configuration	Error type	Application data
$6E_h$	see EN 13757-3	see EN 13757-3	see EN 13757-3	XX_h	Further error information
1 byte	1 byte	1 byte	2 bytes	1 byte	n bytes

9.8.2 Error type

9.8.2.1 List of Error types

Table 70 gives the values that shall be selected according to Error type.

Table 70 — Error type

Error type	Designation	Remarks
00_h	Unspecified error	Data missing or unspecified error
01_h	No application	Unimplemented CI-field
11_h	No function	Function not implemented
12_h	Data error	Data to be supplied not available
$F1_h$ -FF_h	Manufacturer specific	Manufacturer specific error information

The different error types are detailed in the subsequent subclauses.

9.8.2.2 No application

This error status shall be returned by the Application Layer if the requested application CI-field is not implemented in the node. The type field shall be followed by a copy of the incorrect CI-field.

9.8.2.3 No function

This error status shall be returned by the Application Layer if the requested function, that is a defined function, is not implemented. The type field shall be followed by a copy of the value of the un-implemented function field.

9.8.2.4 Data error

This error status shall be returned by the Application Layer if the data provided to the Application Layer are incorrect.

9.9 Management Functions

9.9.1 General

To be able to configure and handle the repeater, a Management Function shall be implemented in the Application Layer. It is, using this Management Function, possible to add meters to or remove meters from the repeater, read out status information about the repeater, handle the lists of the repeater etc. This requires a number of functions which are specified in the following. The format of an Application Layer Management function is given in Table 71 below.

Table 71 — Management Function, data format

CI	Function	Sub Function	Application data
83_h or 89_h	1 byte	1 byte	n bytes

Function field:

The valid values are given in Table 72 below. It may be named F-field as well.

Table 72 — Function field

F-field	Designation	Remarks
30_h	Meter Management	Register or assign Meters to Repeater or remove Meters from Repeater
31_h	Get List	Read out the Repeater Meter List (RML) or the Radio Scan List (RSL)
32_h	Radio Scan List	Clear and / or update the Radio Scan List (RSL)
33_h	Get Repeater Status	Get Repeater Feature Set

Sub-function field:

The F-field is followed by a function specific Sub function field. It may be named SF-field as well. It specifies general control information used in the specific function.

Application data:

Additional data may follow the functional specification.

9.9.2 Data elements

9.9.2.1 General

The clause below defines a number of data elements that are used in one or more of the functions.

9.9.2.2 Mode field

A Mode-field consists of 3 bytes specifying the communication modes, the accessibility and the channel used within a mode. The Mode field is used in some of the functions specified in the following clauses, and in the RML/RSL. The first byte, specified in Table 73, specifies the modes supported by the repeater. This refers to the modes as specified in EN 13757-4:2013. A mode is supported if the corresponding bit is set in byte 1. Byte 2, detailed in Table 74 specifies the accessibility bits and the channel when applicable. Byte 3, detailed in Table 76 specifies the Repeater output power level.

Table 73 — Mode field, byte1, Supported modes

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
RFU[a]			N-Mode	F-Mode	C-Mode	T-Mode	S-Mode
[a] Bits reserved for future use shall by default be 0.							

Table 74 — Mode field, byte2, Accessibility and channels

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
B	A	S	RFU[a]		Channel		
[a] Bits reserved for future use, shall by default be 0							

B: This bit is a copy of Bit B of either the Configuration Word or the Communication Control field from the last received frame (refer to 9.6.4). A set bit signals a bidirectional device which allows a limited or unlimited access (refer to EN 13757-4:2013, Table 27).

A: This bit is a copy of Bit A of either the Configuration Word or the Communication Control field from the last received frame (refer to 9.6.4). A set Bit A signals, if Bit B is set as well, that the device is open for an unlimited access. A set Bit A signals, if bit B is not set, that there temporarily is no access to the meter (refer to EN 13757-4:2013, Table 27).

S: This bit is set if the repeater has ever received a frame from the meter with a set Bit S in either the Configuration Word or the Communication Control field (refer to 9.6.4). Otherwise this bit shall be cleared. A set bit signals the device supports synchronous transmissions conforming to EN 13757-4:2013, 11.6.2.

For the repeater itself, this bit shall be set if the Repeater supports synchronous transmissions conforming to EN 13757-4:2013.

RFU: These bits are reserved for future use and shall be 0 by default.

Channel: Defines for mode N, the channel used, as specified in Table 75 below. The default value shall be used for all other modes.

When Mode is used as an input parameter to a meter management function, the bits B, A and S shall all be "0" as they are read-only values.

Table 75 — Use of Channel bits for Mode N

Channel (bit 2)	Channel (bit 1)	Channel (bit 0)	Channel used for Mode N [a]
0	0	0	invalid (default)
0	0	1	N1a, N2a
0	1	0	N1b, N2b
0	1	1	N1c, N2c
1	0	0	N1d, N2d
1	0	1	N1e, N2e
1	1	0	N1f, N2f
1	1	1	N2g
[a] The default value shall be used for all other modes.			

Table 76 — Mode field, byte 3, Power Level

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

RFU: These bit are reserved for future use and shall be 0 by default.

Power level: These bits specify the Repeater RF transmission power level for each meter. The transmission power level is calculated as; -30 dBm + 2 × Power level (1 .. 62). A Power level of 0 specifies that the preset default power level shall be used. A Power level of 63 specifies that the maximal available or maximal allowed power shall be used.

This power control is used to uniquely adjust the repeater output power in the downlink communications towards the meters, as the meters can be closer or further away from the repeater itself. The power control increases the battery life of the repeater, reduces radio channel interference and prevents blocking of meters close to the repeater.

The power level for all modes is defined using a 6 bit value. The transmission power level is calculated by -30 dBm + 2 × Power Level (1…62). This gives a range from -28 dBm to +94 dBm. Note, the maximum allowed transmission power depends on the mode, refer EN 13757-4.

If a device supports a maximum available output power lower than the requested power, the maximum available power shall be used. If a device supports a minimum available output power higher than the requested power, the minimum available power shall be used. The device shall never use a higher power than the maximum allowed power defined for each mode in EN 13757-4.

9.9.2.3 Time interval

The repeater is not required to support a real time clock but shall be able to calculate time intervals. A Time interval is an unsigned integer. It is used to specify the interval in synchronized transmissions. It specifies the interval in 2 sec. ticks.

9.9.2.4 CRC Calculation

The columns of the stored tables support a CRC-checksum to verify the content of the specific columns. The CRC-checksum shall be calculated over the selected column starting from the first byte (LSB) of the first line of data to the last byte (MSB) of the last line used.

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

The initial value is: 0

The final CRC is complemented

NOTE The applied CRC-polynomial is identical with the CRC used in the Data Link Layer of the EN 13757-4.

9.9.3 Meter Management

9.9.3.1 General

This function is used to add a meter or to remove a meter from the Repeater Meter List (RML). Depending on the selected settings the added meter is either only registered (Meter registration) or registered and assigned (Meter Assignment). The SF-field specifies the action to be made to the specified meter ID’s. If this function is used to add a meter to the RML that is already included in the list, the entry in the RML shall be updated with the new properties i.e. Assigned repetition, Registered repetition etc.

It is optionally possible to specify which communication mode the meter is using. The mode is specified in the mode field. The values of this field are detailed in 9.9.2.2.

It is further possible to specify the transmission interval the meter is using for its synchronous transmissions. This enables the repeater to stop scanning for the meter before the total maximum transmission interval specified in EN 13757-4. This will save power.

If more than one meter ID is included in the frame, the same conditional information on communication mode and transmission interval refers to all meter ID's.

9.9.3.2 Request

The format of the Meter Management request is given in Table 77 below.

Table 77 — Meter Management request format

CI-field	F-field	SF-field	(Mode)	(TX-interval)	n × Meter ID
83_h	30_h	1 byte	(3 bytes)	(2 bytes)	n × 8 bytes

The Mode and TX interval fields are conditional. They are only present if the corresponding bits are set in the SF-field. The content of the different fields is as follows:

SF- field:

The function of the different bits in the SF-field is shown in Table 78 below.

Table 78 — SF-field allocation

bit 7	bit6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
RFU			ACC-NR required	TX-interval used	Mode used	Action	

RFU: These bits are reserved for future use and shall be 0 by default.

ACC-NR req. The Repeater shall send an additional ACC-NR before the expected synchronous meter transmission.

TX-interval: The TX-interval field is included in the request if the bit is set.

Mode used: The Mode-field is included in the request if this bit is set.

Action: Specifies the action to perform;

- 0 0 Delete Meter from RML
- 0 1 Register Meter to RML
- 1 0 Assign Meter to RML
- 1 1 Reserved for future use.

Mode:

This field is only included in the frame if specified in the SF-field. The purpose of the different bits is specified in 9.9.2.2.

TX-interval:

This field is only included in the frame if this is specified in the SF-field. This field specifies the transmission interval of the synchronized transmissions, the meters with the meter ID's in the frame is using. The interval is specified as in 9.9.2.3 and thereby directly specifying the value of <n> used in the calculation of the transmission interval specified in EN 13757-4. If a transmission interval is specified, then the meter(s) uses a transmission interval less than or equal to the specified interval. If i.e. the value is set to 8, the meters with the meter ID’s in the frame transmits with an interval of 2, 4, 6, 8, 10, 12, 14 or 16 seconds. If this field is not included in the frame, the maximum transmission interval specified in EN 13757-4 shall be assumed.

Meter ID:

The rest of the request contains n set of Meter-ID's. Each Meter ID specifies the Link Layer Address of a specific Meter. The format of the Link Layer Address is given in EN 13757-3:2013, 5.13 (Manufacturer, Identification number, Version, Device type). The set-up specified in the request is applicable to the communication with all of the meters listed.

9.9.3.3 Response:

The format of the Management response is given in Table 79 below.

Table 79 — Management response format

CI-field	F-field	SF-field	(Error report)
89_h	30_h	1 byte	(1 byte)

The error report field is conditional.

SF-field:

The function of the different bits in the SF field is shown in Table 80 below.

Table 80 — SF-field allocation

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

Error: The request was successful if this bit is not set. The response will contain an error byte when this bit is set.

RFU: These bits are reserved for future use and shall be 0 by default.

Error report:

This field is only included in the frame if the Error bit is set in the SF field. The different bits are allocated as shown in Table 81. One or more bits may be set.

Table 81 — Error report allocation

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
Man. Spec.	RFU/Man[a]				Unsup. Mode	Unsup. TX-int.	Action error

[a] The allocation of these bits depends on whether or not bit 7 is set.

Man. Spec: A manufacturer specific error type has occurred

0 No manufacturer specific error information

1 Manufacturer specific error information included

RFU/Man: when bit 7 = 0, reserved for future use and shall then be 0 by default.

when bit 7 = 1, manufacturer specific information.

Unsup.Mode The selected Mode or the selected channel is not supported.

Unsup.Tx-int The TX-interval specified in the request is not supported.

Action Error: No changes made to the RML. This is the response to a delete action if the specified meter was not found. This is the response to a assign or register action, if the RML was full.

9.9.4 Get List

9.9.4.1 General

This function is used to read out the Repeater Meter List (RML) or the Radio Scan List (RSL). The selection of which of the two lists the frame is applied to, is specified in the SF-field.

The SF-field further specifies if the frame is a request for control information or data values. When reading out control information from the list, general information about the size and the structure of the list is returned. If data values are read out, both request and response clearly specify which part of the list is requested and responded. If more data are requested than can be contained in a single response frame, the function makes use of multi-messages as described below.

The format of the response depends on whether data or control information was requested. There is a separate section for each type of response.

9.9.4.2 Request:

The format of the Get List request is given in Table 82 below.

Table 82 — Get List request format

CI-field	F-field	SF-field	(SFLN)	(NOL)	(CS)
83_h	31_h	1 byte	(2 bytes)	(2 bytes)	(2 bytes)

The fields in SFLN, NOL and CS are conditional. They are only present if the corresponding bits are set in the SF-field. The content of the different fields is as follows:

SF- field:

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

Table 83 — SF-field allocation

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
RFU				More data	Data / Control	List selection	

RFU: These bit are reserved for future use and shall be 0 by default.

More data: The bit shall always be 0 in a request.

Data/Control: Specifies whether control or data shall be fetched.

1 It is a request for Control information.

0 It is a request for Data values.

List selection: Selects the type of list to access.

0 0 Access the RML

0 1 Access the RSL

1 0 Reserved for future use

1 1 Reserved for future use.

SFLN – Start From Line Number:

This field is only included in the frame, if Data values (bit 2 = 0) is selected in the SF-field. It specifies the line of the selected list, where the response from the repeater shall start from.

NOL – Number of Lines:

This field is only included in the frame, if Data values (bit 2 = 0) is selected in the SF-field. It specifies the number of lines that shall be read out in the response from the repeater.

CS – Column Selection:

This field is only included in the frame, if Data values (Bit 2 = 0) is selected in the SF-field. It selects, by a bit mask which of the maximum number of 16 columns that shall be read out in the response from the repeater. Each bit in this 16 bit field represents one column of the list. The least significant bit represent column 1, the most significant bit represent Column 16.

9.9.4.3 Response, Control information

The format of the Get List response for Control Information is given in Table 84 below.

Table 84 — Get List response format, Control Information

CI-field	F-field	SF-field	UNOL	MNOL	AC	$LOAC_m$	$CRCAC_m$
89_h	31_h	1 byte	2 bytes	2 bytes	2 bytes	n×1 byte	n×2 bytes

SF-field:

The function of the different bits in the SF field is shown in Table 85 below. The format of the SF field is the same for Data values.

Table 85 — SF-field allocation

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
RFU				More data	Data / Control	List selection	

RFU: These bits are reserved for future use and shall be 0 by default.

More data: 1 More data available

0 Last block from list.

Data/Control: Specifies whether control or data has been fetched. This determines the format of the rest of the response.

1 Control information is returned,

0 Data values are returned.

List selection: Specifies the type of list that has been accessed.

0 0 An RML has been accessed,

0 1 An RSL has been accessed

1 0 Reserved for future use

1 1 Reserved for future use.

UNOL – Used Number of Lines:

This field is a part of the response of Control Information. It specifies the total number of lines that are currently used in the selected list.

MNOL – Maximum Number of Lines:

This field is a part of the response for Control Information. It specifies the maximum number of lines that the list can hold.

AC – Active Columns:

This field is a part of the response of Control Information. It specifies which of the 16 columns are active in the responding repeater. Each of the bits in this 16 bit field represents one column of the selected list.

$LOAC_m$ – Length of Active Column:

This field is a part of the response of Control Information. The field holds a set of one-byte length values. Each value specifies the column size in bytes of the m active columns of the selected list in the responding repeater.

If there are 5 active columns, then this field holds 5 one-byte wide LOAC-fields. Each of the LOAC-fields specifies length of the data contained in the individual active columns.

$CRCAC_m$ – CRC of Active Column:

This field is a part of the response of Control Information. The field holds a set of CRC-values. Each of the CRC-values covers all of the used lines in the m'th active column of the selected list from the responding repeater.

If there i.e. are 5 active columns, then this field holds 5 two-bytes CRCAC values. This is the CRC's for the data contained in each of the individual active columns. These fields enable the receiver to clearly identify which of the active columns that are unchanged since last readout and thereby enabling the receiver to only read out the updated columns.

9.9.4.4 Response, Data Values

The format of the Get List response for Data values is given in Table 86 below.

Table 86 — Get List response format, Data Values

CI-field	F-field	SF-field	SFLN	NOL	CS	ID CRC	$Line_n$
89_h	31h	1 byte	2 bytes	2 bytes	2 bytes	2 bytes	n × $\sum LOAC_m$ bytes

SF- field:

The function of the different bits in the SF-field is the same as for Control information. The details are given in Table 85 above.

SFLN – StartFromLineNumber:

This field is a part of the response of Data Values. The field specifies the line of the selected list, where this response from the repeater starts from.

NOL – NumberOfLines:

This field is a part of the response of Data Values. The field specifies the number of lines that are included in this response from the repeater.

CS – ColumnSelection:

This field is a part of the response of Data Values. This field specifies which of the maximum of 16 columns that are read out in this response from the repeater. Each bit in this 16 bit field represents one column of the list. The least significant bit represent column 1, the most significant bit represent Column 16.

ID CRC:

This field is a part of the response of Data Values. This field is a two-bytes field containing a CRC-value covering all used lines in the first column of the selected list. This column contains the meter ID's. This field is always a part of the response data values from the repeater. This field enables the receiver to clearly identify if any of the meters in the list has changed since last readout. Thereby enabling the receiver to only read out single columns from the list not including column 1 containing the meter ID's.

$Line_n$:

This field is a part of the response of Data Values. This is the actual data from the Repeater. It has n elements of data as specified in NOL. The length of each element is the number of lines times the sum of the individual column lengths of the columns specified by the CS-field of the frame. Each element contains one line of the list with all the selected columns.

9.9.4.5 Exception handling

If more lines are requested than available in the selected list (SFLN + NOL > UNOL) the repeater shall respond with the available number of lines within the selection.

If lines requested are outside the used part of the selected list (SFLN > UNOL), the NOL-field in the response shall be 0 indicating that no lines are included in the response.

If a column is requested that is not active in the selected list, the corresponding bit of the CS-field of the reply shall be cleared and the request for this column is thereby ignored.

If no active columns are requested in the selected list, the CS-field in the response shall be 0 indicating that no columns are included in the response.

9.9.4.6 Multi-messages:

If more data are requested than can be contained in one single reply frame, multi-messages should be used. In this case the repeater shall response as much data in each frame as possible. Until the last requested data is read out of the repeater, the SF-field should indicate that more data are available in the response. The receiver may use this functionality to request user data as long as the SF-field indicates that more data are available. In this situation of multi-messages each response specify exactly which part of the list is included in the actual frame.

9.9.5 Radio Scan List

9.9.5.1 General

This function is used to handle the Radio Scan List (RSL). During normal Repeater operation all meters that the repeater receives frames from will be added to the RSL. By using this function, it is possible to either clear the RSL, start a new scan for a specified period, or even both.

Together with the request for starting a new scan, a Scan-duration and a communication Mode can be specified to be able to control and limit the scan results.

9.9.5.2 Request:

The format of the Radio Scan List request is given in Table 87 below.

Table 87 — Radio Scan List request format

CI-field	F-field	SF-field	(Mode)	(Scan-duration)
83_h	32_h	1 byte	(3 bytes)	(2 bytes)

The fields Mode and Scan-duration are conditional. They are only present if the corresponding bits are set in the SF-field. The content of the different fields is as follows:

SF-field:

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

Table 88 — SF-field allocation

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
RFU				Scan-dur.	Mode used	Start/ Stop	Clear RSL

RFU: These bits are reserved for future use and shall be 0 by default.

Scan-dur: Whether or not Scan-duration information is a part of the data.

0 Scan duration is not included

1 Scan duration is included.

Mode used: The Mode-field is included in the request if this bit is set.

Start/Stop: Whether or not a scan shall be activated;

0 A radio scan shall be stopped (or not started)

1 A radio scan shall be (re)started.

Clear RSL:. Whether or not the Radio Scan List (RSL) shall be cleared;

0 The RSL shall not be cleared,

1 The RSL shall be cleared.

Mode:

This field is only included in the frame if specified in the SF-field. The purpose of the different bits is specified in 9.9.2.2.

Scan-duration:

This field is only included in the frame if specified in the SF-field. This field is an unsigned integer. It specifies for how long a Repeater shall perform an intense scan. The duration of an intense scan is in 'ticks' as specified 9.9.2.3.

9.9.5.3 Response:

The format of the Radio Scan function response is given in Table 89 below.

Table 89 — Radio Scan response format

CI-field	F-field	SF-field	(Error report)
89_h	32_h	1 byte	(1 byte)

The Error report is conditional.

SF-field:

The function of the different bits in the SF-field is shown in Table 90 below.

Table 90 — SF-field allocation

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

Error: Whether or not an error occurred;

0 The request was successful, no error data follows.

1 An error occurred. The response will contain an error byte with further information.

RFU: These bits are reserved for future use and shall be 0 by default.

Error report:

This field is only included in the frame if the Error bit is set in the SF-field. The different bits are allocated as shown in Table 91. One or more bits can be set.

Table 91 — Error report allocation

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
Man. Spec	RFU/Man[a]				RFU	Other	Overflow
[a] The allocation of these bits depends on whether or not bit 7 is set.							

Man. Spec: A manufacturer specific error type has occurred

0 No manufacturer specific error information

1 Manufacturer specific error information included.

RFU/Man: When bit 7 = 0, reserved for future use, shall be 0 by default.

When bit 7 = 1, additional manufacturer specific error information.

RFU: These bits are reserved for future use and shall be 0 by default.

Other: Other non specific error has occurred.

Overflow: Radio Scan List overflow;

0 The full Radio Scan List available

1 More entries for the Radio Scan List than space available. Some entries discarded.

9.9.6 Repeater Status

9.9.6.1 General

This function is used to read out the status of the Repeater itself and the links of registered Meters.

9.9.6.2 Request

The format of the Get Repeater Status request is given in Table 92 below.

Table 92 — Get Repeater status request format

CI-field	F-field	SF-field
83_h	33_h	1 byte

The content of the different fields is as follows:

SF-field:

The function of the different bits in the SF-field is shown in Table 93 below.

Table 93 — SF-field allocation

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
RFS req.	RFU						

RFS req. Whether or not the Repeater Feature Set, RFS, shall be included in the response;

0 The RFS shall not be included in the response

1 The RFS shall be included in the response

RFU: These bits are reserved for future use and shall be 0 by default.

9.9.6.3 Response

The format of the Get Repeater Status response is given in Table 94 below.

Table 94 — Get Repeater Status response format

CI-field	F-field	SF-field	STSF	CNORD	MNORD	NOTIL	NOPIL	(RFS)
89_h	33_h	1 byte	1 byte	2 bytes	2 bytes	1 byte	1 byte	(8 bytes)

The RFS field is conditional

SF-field:

The function of the different bits in the SF-field is shown in Table 95 below.

Table 95 — SF field allocation

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
RFS Exists	RFU						RML full

RFS exist: This bit is set if an RFS field is included in the response.

RFU: These bits are reserved for future use and shall be 0 by default.

RML full: This bit is set if there are no more empty locations in the RML.

STSF – Status-Field:

The Status Field STSF is a one-byte field. It shall be used according to the Status-field in EN 13757-3:2013, Table 7.

CNORD – Current Number of Repeated Devices:

This value describes the current number of units in the Repeater Meter List.

RNORD – Remaining Number of Repeated Devices:

This value describes the number of additional Meters that may be added in the Repeater Meter List of this Repeater. If this value drops to 0 the flag RML full in the SF field shall be set as well.

NOTIL – Number of Temporary Interrupted Links:

This value describes the number of temporary broken links between the Repeater and Meters. The repeater still tries to re-establish a link to these Meters. A value of 255 signals that more than 254 links are interrupted.

NOPIL – Number of Permanently Interrupted Links:

This value describes the number of permanently broken links between Repeater and Meters. The Repeater has stopped to re-establish a link to these Meters. A value of 255 signals that more than 254 links are interrupted.

RFS – Repeater Feature Set:

This Field provides information about the main features of this type of Repeater. It is subdivided as shown in Table 96 below:

Table 96 — Repeater Feature Set

byte 0	**byte 1**	**byte 2**	**byte 3**	**byte 4**	**byte 5**	**byte 6**	**byte 7**
Supported Modes & power level			Preferred mode and power level			Trans. inter.	RFU

Sup. Modes: The different modes and power levels supported by the Repeater. The content formatted as specified in 9.9.2.2 for the Mode-field.

Pref. Modes: The preferred modes and the current power levels of the Repeater. The content formatted as specified in 9.9.2.2 for the Mode-field.

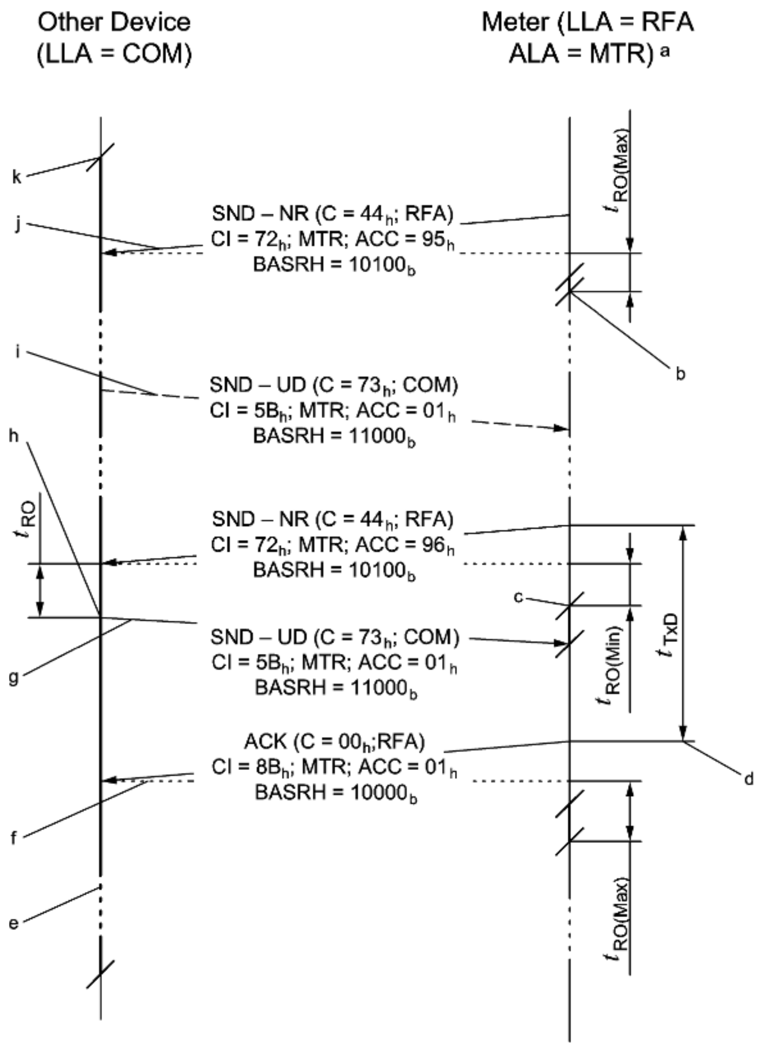
Trans. inter: The transmission interval for the Repeater in the preferred mode. Specified in ticks as defined in 9.9.2.3

RFU: This bit is reserved for future use and shall be 0 by default.

Annex A
(informative)

Timing Diagrams for a Single Hop Repeater

The timing for the use of a Single Hop repeater is shown in the Figures A.1 through A.8.



Key

a LLA = Link layer address, ALA= Application layer address. In this example the LLA is the Address from the RF-adapter "RFA" and the Meter Application address is "MTR".

b The reception window of the Meter closes after t_{RO}(Max) e.g. 3 ms for T-Mode.

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

d A delay of t_{TxD} sec.

e Time gap.

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

g The Other Device with address "COM" sends a message of type "Send User data“ (C-Field=53_h) to the Meter with address "MTR" and uses an Access number "1". The settings of the control bits B, A, S, R and the H-Bit are shown as binary data.

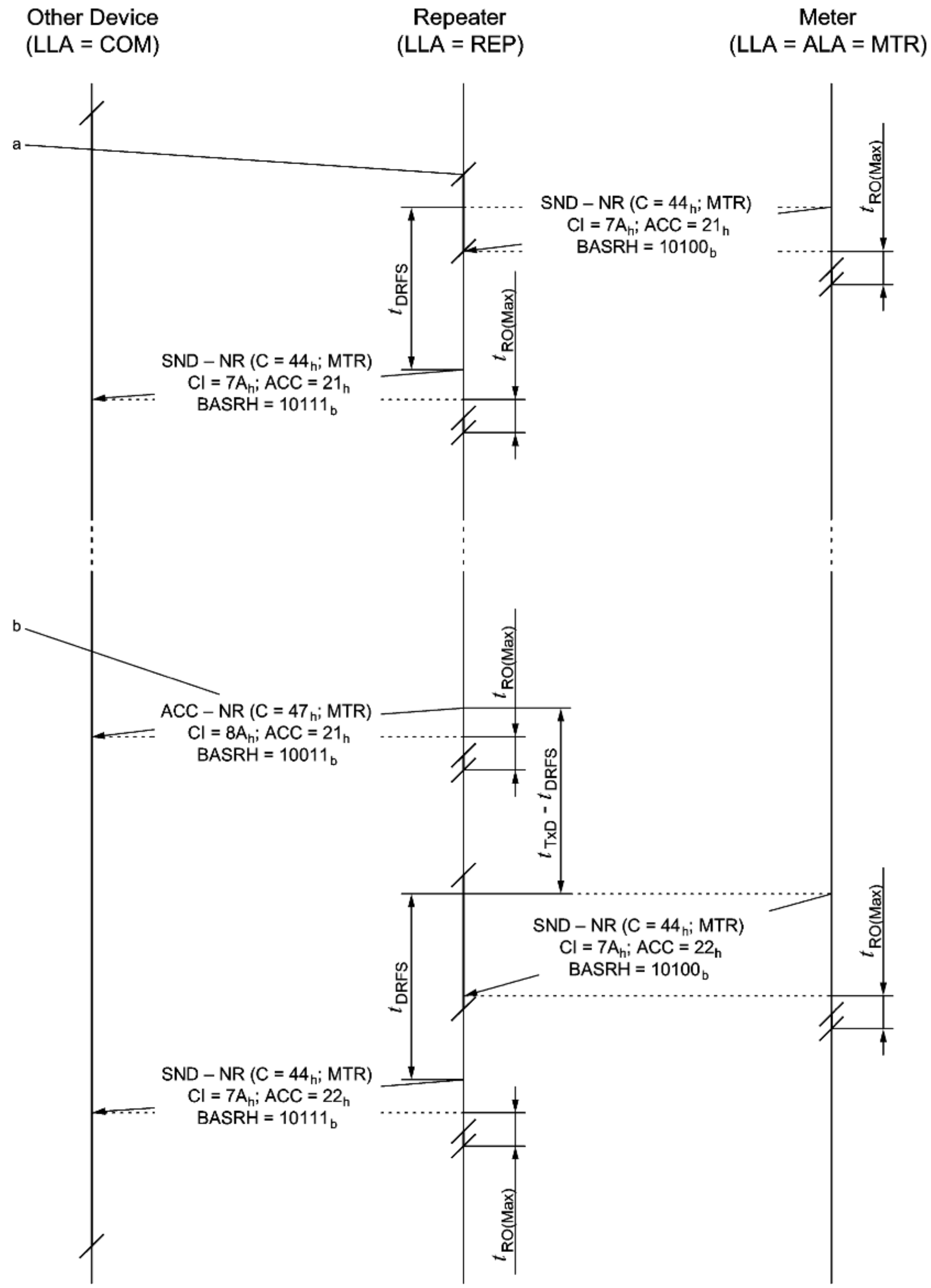
h The Other Device has to send the answer within t_{RO} (between 2'nd and 3'rd ms for T-Mode)

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

j The continuous line means the message was successful received.

k The Other Device has the receiver continuously open!

Figure A.1 — Reference transfer

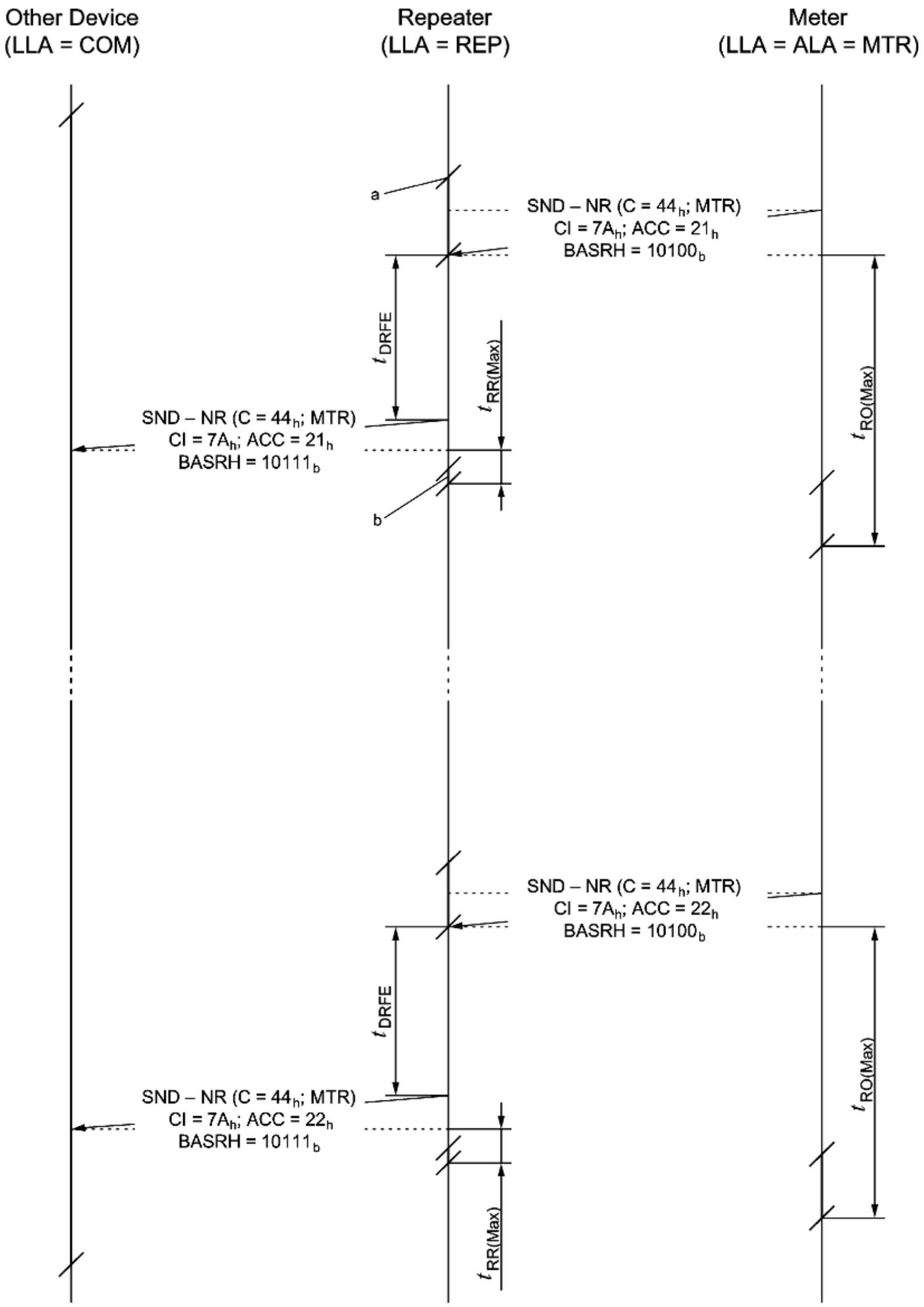


Key

a The Repeater opens the receiver for a synchronous Meter transmission of an assigned Meter.

b If the meter uses a slow transmission interval, then the assigned Repeater may mark the anticipated Meter trans-mission by an additional ACC-NR in front of the expected Meter transmission by using the old access number.

Figure A.2 — SND-NR via assigned battery BSHR (mode S,T)

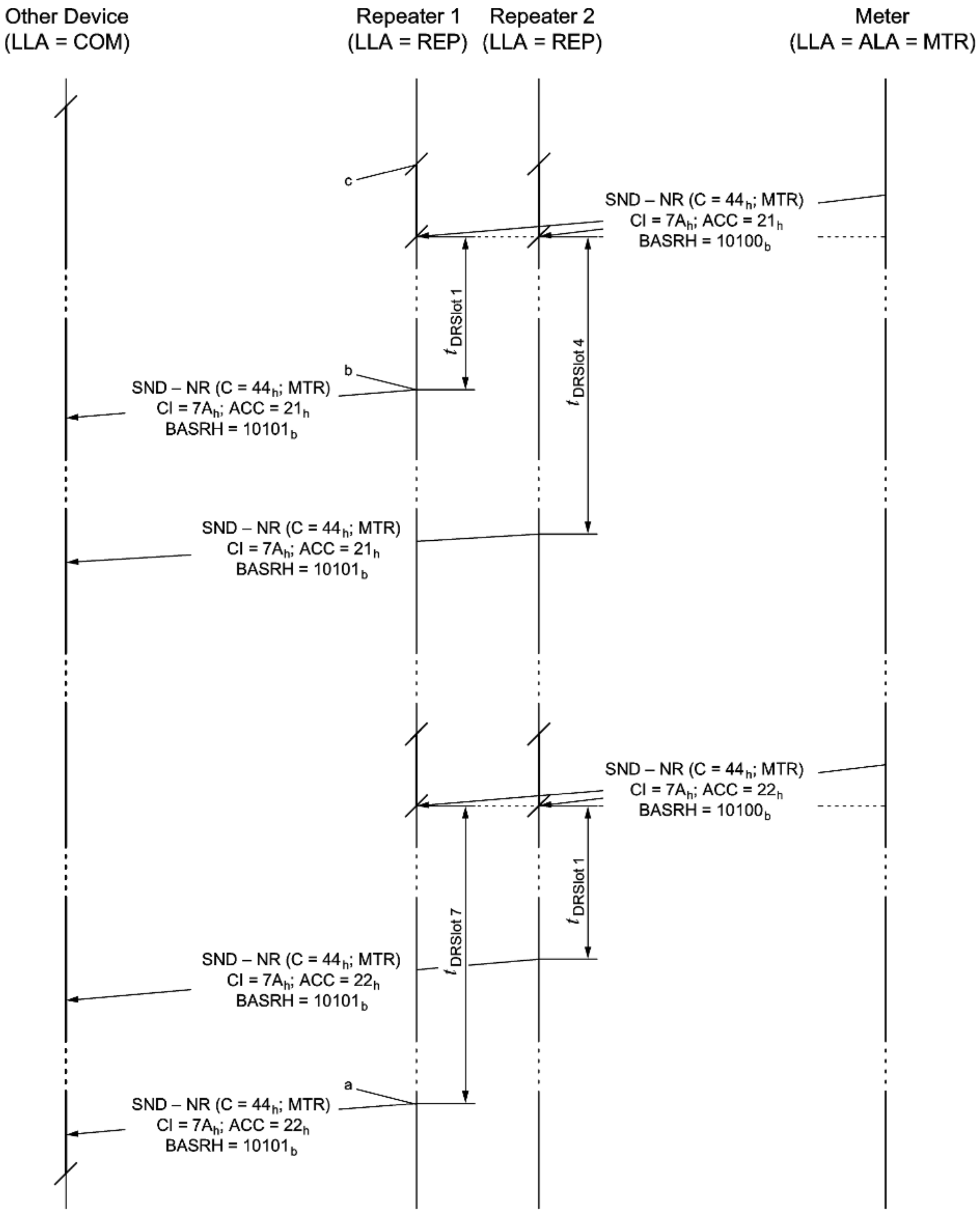


Key

a The Repeater opens the receiver for a synchronous Meter transmission of an assigned Meter.

b The Repeater opens the receiver for the reception of a reply from Other Device after a response delay (t_{RR}).

Figure A.3 — SND-NR via assigned battery BSHR (optimized repetition using mode C, N, F)



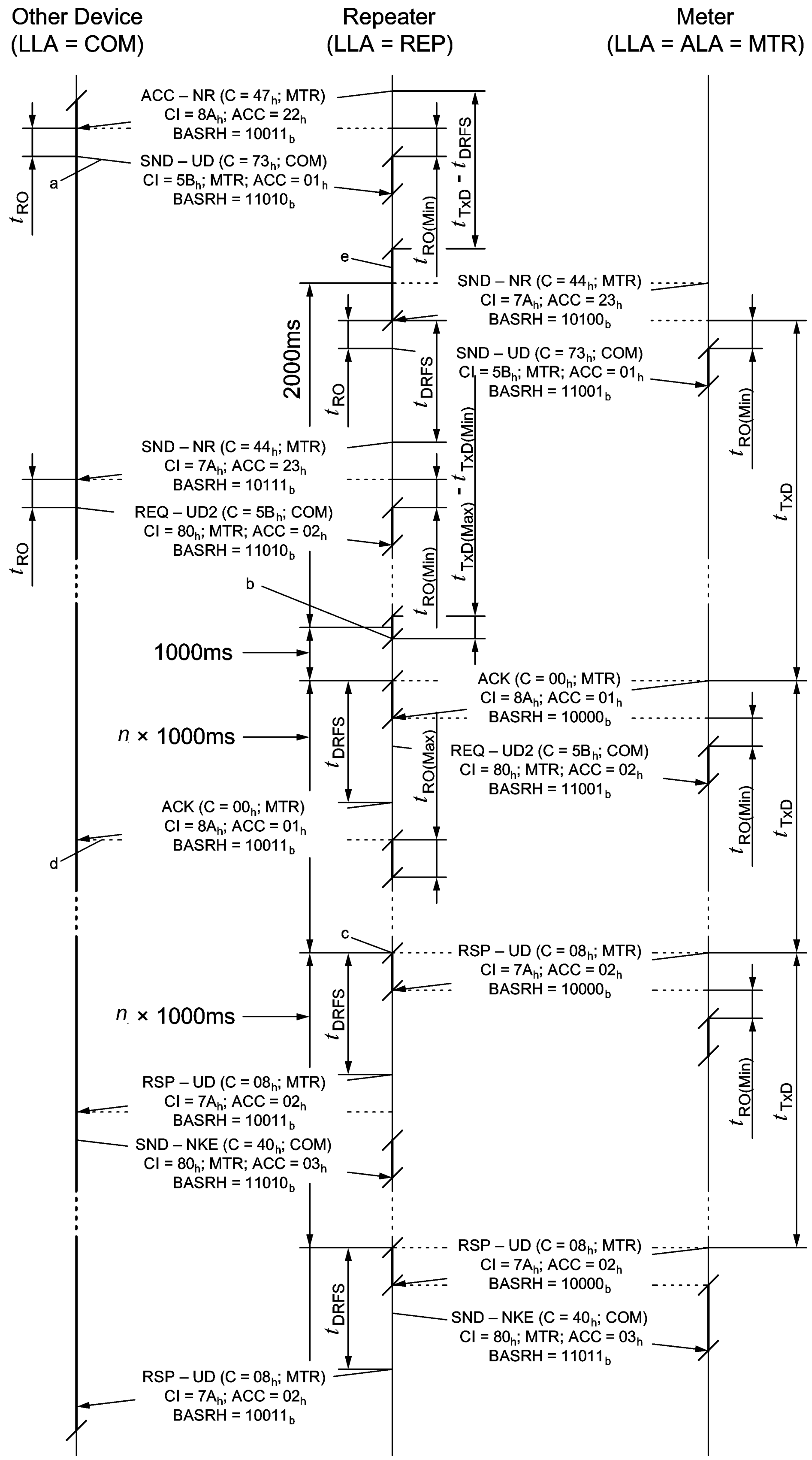
Key

a The registered Repeater randomly selects a new optional timeslot for every repetition of registered Meters.

b The registered Repeater randomly selects optionally timeslots for registered Meters.

c The Repeater opens the receiver for a synchronous Meter transmission of a registered Meter.

Figure A.4 — SND-NR via registered battery BSHR (using optional time slots)



Key

a The Other Device gets a command for this Meter. It forwards the command in this access slot.

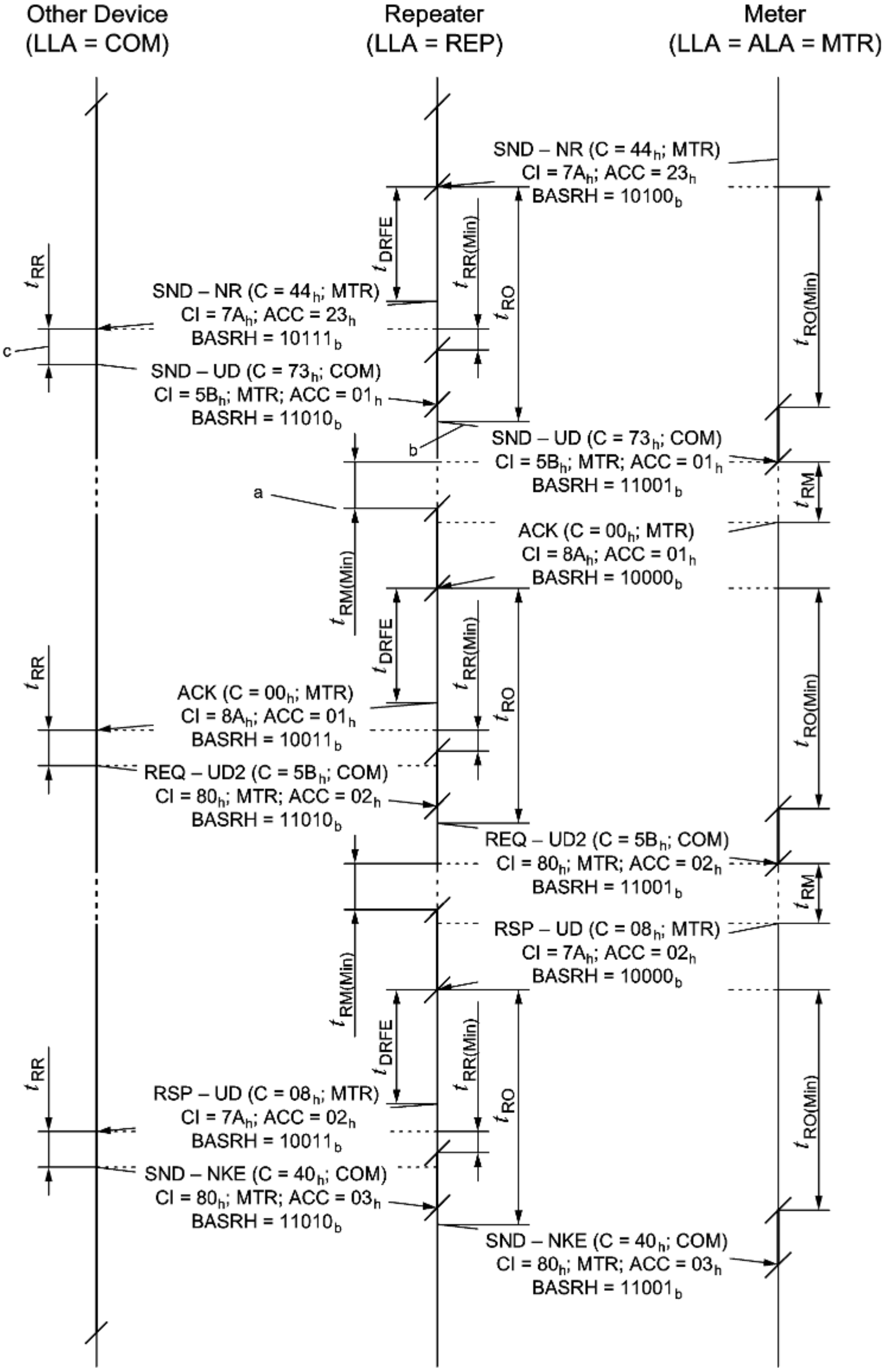
b The Repeater learns the dedicated delay of this Meter by opening the receiver at each of the *n* seconds (here with n=3).

c The Repeater now applies the correct delay of the Meter before it opens the receiver.

d The Other Device may wait for the reception of the last response before it closes the connection. Therefore the Master sends nothing within this time slot.

e The Repeater automatically opens the receiver for all assigned Meters at the determined synchronous meter transmission access slots.

Figure A.5 — SND-UD via an assigned battery powered BSHR (with a meter delay of *n*=3 using mode S or T)



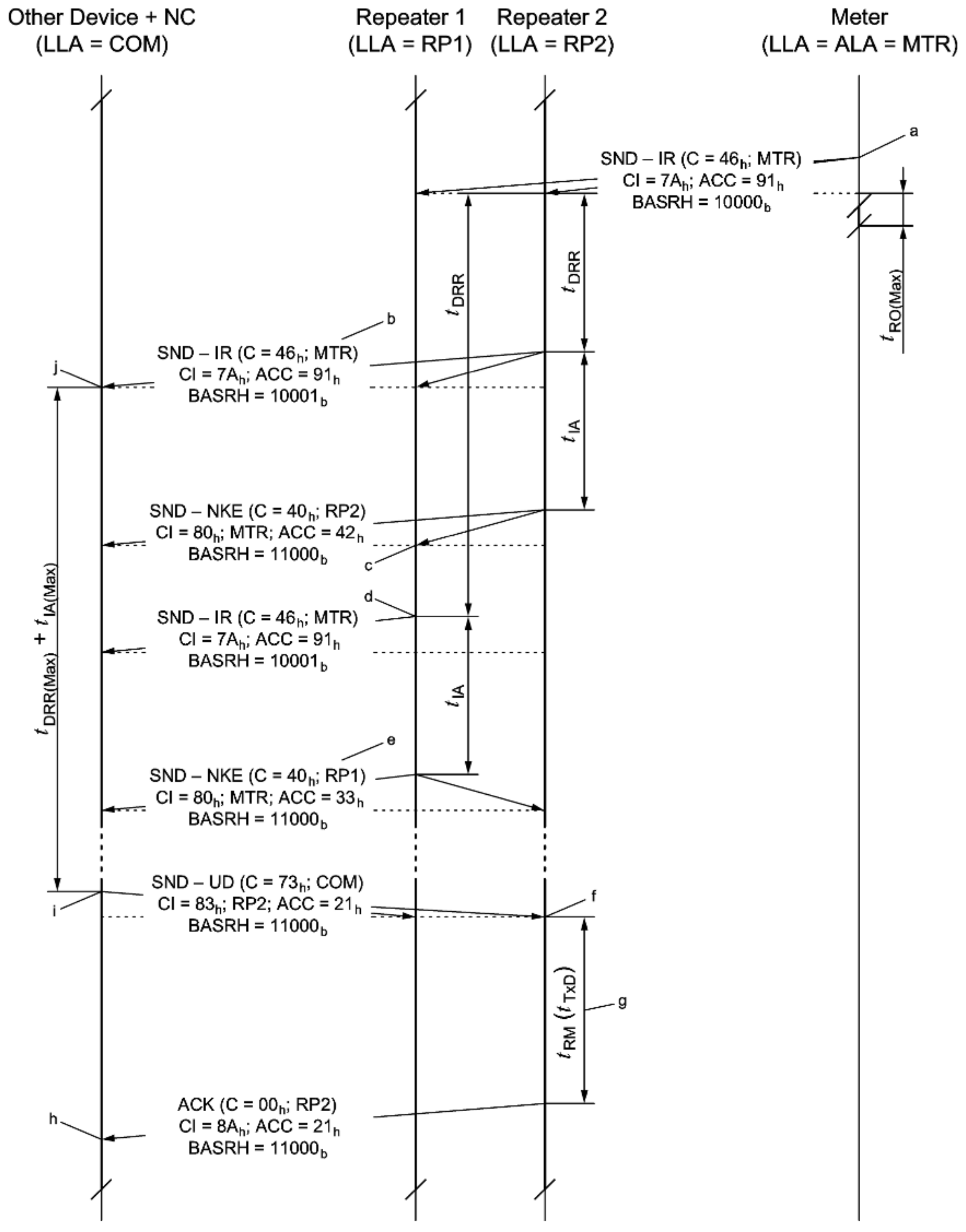
Key

a The Repeater listens for a response from the Meter after a response delay ($t_{RM(Min)}$).

b The Repeater repeats the frame from Other Device to Meter after a response delay (t_{RO}) after the Meter transmission.

c The Other Device responds after a response delay (t_{RR}).

Figure A.6 — SND-UD via a assigned battery BSHR (optimized repetition using mode C, N)



Key

a During the Installation mode the Meter generates periodical frames of the type "Installation request" until the reception of either the Installation "Confirmation" (CNF-IR) or a time out.

b The Repeater only accepts frames with R = 0.

c The unregistered Repeater ignores all frames except those with a $C=44_h$ or a $C=46_h$.

d Every Repeater repeats every frame once with a $C=44_h$ or a $C=46_h$.

e Repeater1 confirms potetial radio-link to the Other Device or an optional Service tool by a "Link reset".

f Repeater2 adds the link address MTR to its Repeat Meter List and set the Assignment Bit. The repeater now has the right to respond to the Meter.

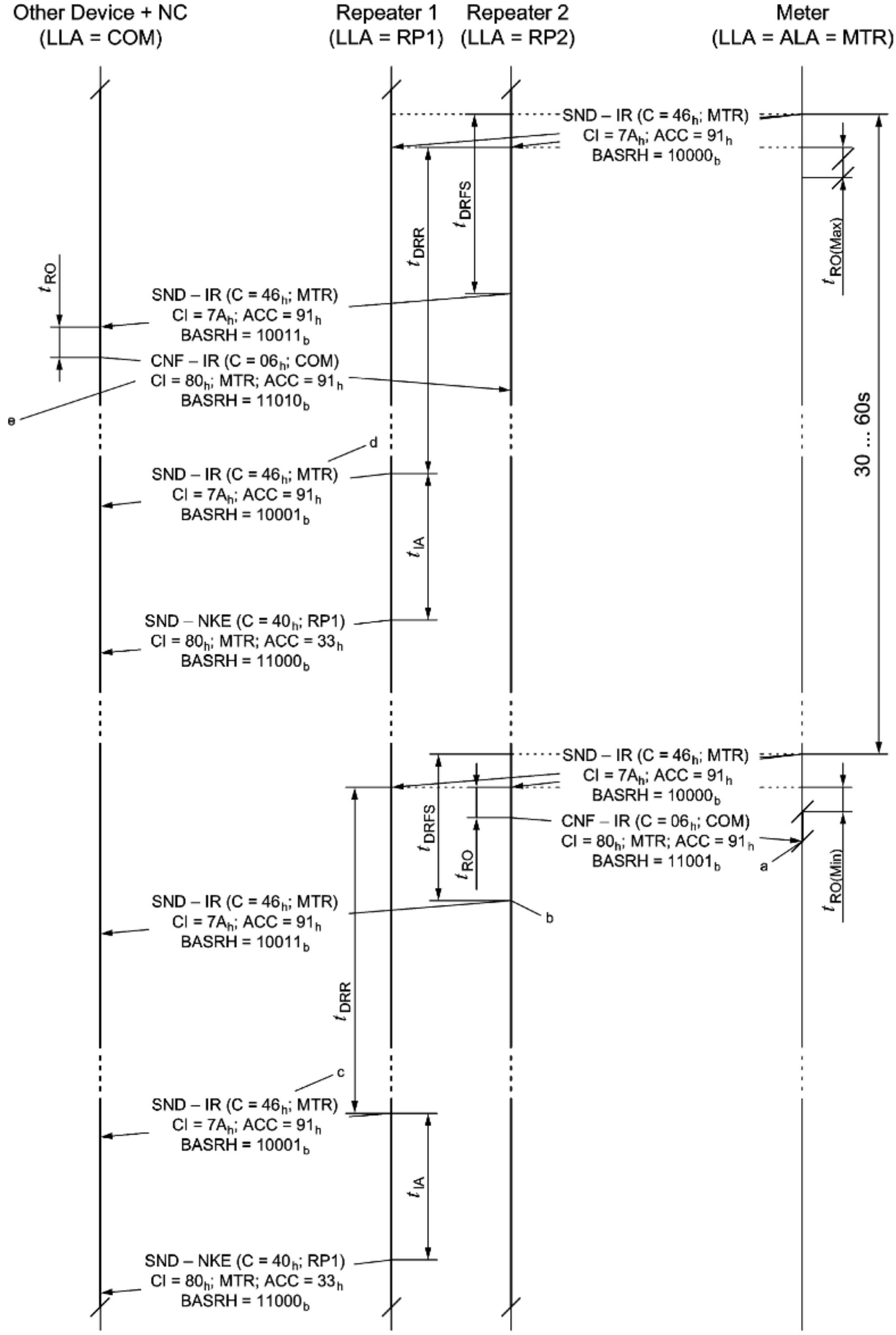
g Meters using modes that do not specify a meter response delay (t_{RM}) use t_{TxD} instead.

h The Repeater confirms the reception of the command.

i All Repeaters have finished the first repetition cycle no later than 30 s after first frame. The Other Device/NC may now select one of the repeaters and send the meter ID and the access rights to the Repeat Meter List of the selected repeater.

j The Other Device will itself not create a SND-NKE. That is why the Hop count bit is not cleared.

Figure A.7 — Installation Procedure with battery powered BSHR (Part 1)



Key

a The bidirectional Meter receives the confirmation and stops the transmission of installation frames.

b The assigned Repeater forwards the stored frame to the meter. Thereafter it repeats the Meter message to Other Device with a fixed delay.

c The unregistered Repeater will repeat any frame with C=44_h or 46_h.

d The unregistered Repeater will repeat any frame with C=44_h or 46_h.

e The Other Device / COM generates a CNF-IR

Figure A.8 — Installation Procedure with battery powered BSHR (Part 2)

Annex B
(informative)

Message examples

B.1 Command to Repeater and response

B.1.1 General

This example shows the details in a command (SND_UD) from an Other Device (COM Controller) to the Repeater and the answer from the Repeater (ACK). The repeater is addressed using the Extended Link Layer. The actual command, shown in Table B.1 clears the Radio Scan List of the repeater. The response from the repeater is shown in Table B.2. See 9.9.5 for a detailed description.

B.1.2 Configuration

The detailed frame information listed in the below is based on the following configuration information.

Controller:

— Manufacturer ID CEN

— Serial number 33445566

— Version 10 (e.g. V. 1.0)

— Detected BSHR-RSSI -80 dBm

Repeater: (type Bi-directional Single Hop Repeater, BSHR)

— Manufacturer ID CEN

— Serial number 12345678

— Version 21 (e.g. V. 2.1)

Meter:

— Media Water

— Manufacturer ID CEN

— Serial number 92752244

B.1.3 Detailed data, command

Table B.1 —SND-UD – From Other Device to Repeater (wM-Bus)

SND_UD (wM-Bus)				
		wM-Bus frame	**COM -> BSHR**	
Byte No	**Field Name**	**Content**	**Bytes [hex] plain**	
1	L Field	Length of data (bytes)	17_h	Linklayer (DLL)
2	C Field	Send user data (SND_UD)	73_h	
3	M Field	Manufacturer code	AE_h	
4	M Field	Manufacturer code	$0C_h$	
5	A Field	Serial No LSB (BCD)	66_h	
6	A Field	Serial No (BCD)	55_h	
7	A Field	Serial No (BCD) (=33445566)	44_h	
8	A Field	Serial No MSB (BCD)	33_h	
9	A Field	Version (or Generation number)	$0A_h$	
10	A Field	Device type (COM)	31_h	
11	CRC 1		AE_h	
12	CRC 1		17_h	
13	CI Field	Extended Link Layer	$8E_h$	Extendet Link Layer (ELL)
14	CC-Field	Bi-Directional, Accessibility	84_h	
15	Access No.	Transmission counter	56_h	
16	M2-Field	Manufacturer code	AE_h	
17	M2-Field	Manufacturer code	$0C_h$	
18	A2-Field	Serial No LSB (BCD)	78_h	
19	A2-Field	Serial No (BCD)	56_h	
20	A2-Field	Serial No (BCD)	34_h	
21	A2-Field	Serial No MSB (BCD)	12_h	
22	A2-Field	Version (or Generation number)	15_h	
23	A2-Field	Device type (Medium=BSHR)	33_h	
24	CI Field	83_h Network Management Application	83_h	APL
25	F-Field	Function Code	32_h	
26	SF-Field	Clear Radio scan list	01_h	
27	CRC 2		DF_h	DLL
28	CRC 2		$A7_h$	

B.1.4 Detailed data, acknowledge

Table B.2 — ACK – From Repeater to Other Device (wM-Bus)

ACK (wM-Bus)				
		wM-Bus frame	**BSHR -> COM**	
Byte No	**Field Name**	**Content**	**Bytes [hex] plain**	
1	L Field	Length of data (bytes)	$0C_h$	Data Link Layer (DLL)
2	C Field	Acknowledge	00_h	
3	M Field	Manufacturer code	AE_h	
4	M Field	Manufacturer code	$0C_h$	
5	A Field	Serial No LSB (BCD)	78_h	
6	A Field	Serial No (BCD)	56_h	
7	A Field	Serial No (BCD) (=12345678)	34_h	
8	A Field	Serial No MSB (BCD)	12_h	
9	A Field	Version (or Generation number)	15_h	
10	A Field	Device type (Medium=BSHR)	33_h	
11	CRC 1		29_h	
12	CRC 1		BE_h	
13	CI Field	Extended Link Layer	$8C_h$	Extended Link Layer (ELL)
14	CC-Field	Bi-Directional, Accessibility	84_h	
15	Access No.	Transmission counter	56_h	
16	CRC 2		69_h	DLL
17	CRC 2		86_h	

B.2 Readout of Radio Scan List

B.2.1 General

This example shows a communication sequence between the Other Device (COM Controller) and the Repeater. First the Other Device sends a command (SND_UD) to read the RadioScanList, see Table B.3. The Repeater answers with an acknowledge (ACK), see Table B.4. Then the Other Device requests the data (REQ_UD2), see Table B.5, and the Repeater responds (RSP_UD), see Table B.6, with the content of the RadioScanList. The Repeater is addressed using the Extended Link Layer. See EN 13757-4:2013, 12.2 for a detailed description.

B.2.2 Configuration

The detailed frame information listed in the below is based on the following configuration information.

Controller:

— Manufacturer ID CEN

— Serial number 33445566

— Version 10 (e.g. V. 1.0)

— Detected BSHR-RSSI -80 dBm

Repeater: (type Bidirectional Single Hop Repeater, BSHR)

— Manufacturer ID CEN

— Serial number 12345678

— Version 21 (e.g. V. 2.1)

Meter:

— Media Water

— Manufactuer ID CEN

— Serial number 92752244

— Version 41

B.2.3 Detailed data, command

Table B.3 — SND-UD – From Other Device to Repeater (wM-Bus)

SND-UD (wM-Bus)				
		wM-Bus frame	**COM -> BSHR**	
Byte No	**Field Name**	**Content**	**Bytes [hex]**	
1	L Field	Length of data (bytes)	16_h	Data Link Layer (DLL)
2	C Field	Send user data (SND_UD)	73_h	
3	M Field	Manufacturer code	AE_h	
4	M Field	Manufacturer code	$0C_h$	
5	A Field	Serial No LSB (BCD)	66_h	
6	A Field	Serial No (BCD)	55_h	
7	A Field	Serial No (BCD) (=33445566)	44_h	
8	A Field	Serial No MSB (BCD)	33_h	
9	A Field	Version (or Generation number)	$0A_h$	
10	A Field	Device type (COM)	31_h	
11	CRC 1		95_h	
12	CRC 1		84_h	
13	CI Field	Extended Link Layer	$8E_h$	Extended Link Layer (ELL)
14	CC-Field	Bi-Directional, Accessibility	84_h	
15	Access No.	Transmission counter	57_h	
16	M2-Field	Manufacturer code	AE_h	
17	M2-Field	Manufacturer code	$0C_h$	

SND-UD (wM-Bus)				
		wM-Bus frame	**COM -> BSHR**	
Byte No	**Field Name**	**Content**	**Bytes [hex]**	
18	A2-Field	Serial No LSB (BCD)	78_h	
19	A2-Field	Serial No (BCD)	56_h	
20	A2-Field	Serial No (BCD)	34_h	
21	A2-Field	Serial No MSB (BCD)	12_h	
22	A2-Field	Version (or Generation number)	15_h	
23	A2-Field	Device type (Medium=BSHR)	33_h	
24	CI Field	83_h Network Management Appl.	83_h	TPL
25	F-Field	Function Code	31_h	APL
26	SF-Field	Radio scan list, Control Information	05_h	
27	CRC 2		DF_h	DLL
28	CRC 2		$A7_h$	

B.2.4 Detailed data, acknowledge

Table B.4 — ACK – From Repeater to Other Device (wM-Bus)

ACK (wM-Bus)				
		wM-Bus frame	**BSHR -> COM**	
Byte No	**Field Name**	**Content**	**Bytes [hex]**	
1	L Field	Length of data (bytes)	19_h	Data Link Layer (DLL)
2	C Field	Acknowledge	00_h	
3	M Field	Manufacturer code	AE_h	
4	M Field	Manufacturer code	$0C_h$	
5	A Field	Serial No LSB (BCD)	78_h	
6	A Field	Serial No (BCD)	56_h	
7	A Field	Serial No (BCD) (=12345678)	34_h	
8	A Field	Serial No MSB (BCD)	12_h	
9	A Field	Version (or Generation number)	15_h	
10	A Field	Device type (Medium=BSHR)	33_h	
11	CRC 1			
12	CRC 1			
13	CI Field	Extended Link Layer	$8C_h$	Extended Link Layer (ELL)
14	CC-Field	Bi-Directional, Accessibility	84_h	

ACK (wM-Bus)				
		wM-Bus frame	**BSHR -> COM**	
Byte No	**Field Name**	**Content**	**Bytes [hex]**	
15	Access No.	Transmission counter	57_h	
16	CRC 2			DLL
17	CRC 2			

B.2.5 Detailed data, request

Table B.5 — REQ-UD2 – From Other Device to Repeater (wM-Bus)

REQ-UD2 (wM-Bus)				
		wM-Bus frame	**COM -> BSHR**	
Byte No	**Field Name**	**Content**	**Bytes [hex]**	
1	L Field	Length of data (bytes)	21_h	Data Link Layer (DLL)
2	C Field	Request user data class 2 ($5B_h$ or $7B_h$)	$5B_h$	
3	M Field	Manufacturer code	AE_h	
4	M Field	Manufacturer code	$0C_h$	
5	A Field	Serial No LSB (BCD)	66_h	
6	A Field	Serial No (BCD)	55_h	
7	A Field	Serial No (BCD) (=33445566)	44_h	
8	A Field	Serial No MSB (BCD)	33_h	
9	A Field	Version (or Generation number)	$0A_h$	
10	A Field	Device type (COM)	31_h	
11	CRC 1			
12	CRC 1			
13	CI Field	Extended Link Layer	$8E_h$	Extended Link Layer (ELL)
14	CC-Field	Bi-Directional, Accessibility	84_h	
15	Access No.	Transmission counter	58_h	
16	M2-Field	Manufacturer code	AE_h	
17	M2-Field	Manufacturer code	$0C_h$	
18	A2-Field	Serial No LSB (BCD)	78_h	
19	A2-Field	Serial No (BCD)	56_h	
20	A2-Field	Serial No (BCD)	34_h	
21	A2-Field	Serial No MSB (BCD)	12_h	
22	A2-Field	Version (or Generation number)	15_h	

REQ-UD2 (wM-Bus)				
		wM-Bus frame	**COM -> BSHR**	
Byte No	**Field Name**	**Content**	**Bytes [hex]**	
23	A2-Field	Device type (Medium=BSHR)	33_h	
24	CRC 2			DLL
25	CRC 2			

B.2.6 Detailed data, response

Table B.6 — RSP-UD – From Repeater to Other Device (wM-Bus)

RSP-UD (wM-Bus)				
		wM-Bus frame	**BSHR -> COM**	
Byte No	**Field Name**	**Content**	**Bytes [hex]**	
1	L Field	Length of data (bytes)	19_h	Data Link Layer (DLL)
2	C Field	Respond user data	08_h	
3	M Field	Manufacturer code	AE_h	
4	M Field	Manufacturer code	$0C_h$	
5	A Field	Serial No LSB (BCD)	78_h	
6	A Field	Serial No (BCD)	56_h	
7	A Field	Serial No (BCD) (=12345678)	34_h	
8	A Field	Serial No MSB (BCD)	12_h	
9	A Field	Version (or Generation number)	15_h	
10	A Field	Device type (Medium=BSHR)	33_h	
11	CRC 1			
12	CRC 1			
13	CI Field	Extended Link Layer	$8E_h$	Extended Link Layer (ELL)
14	CC-Field	Bi-Directional, Accessibility	84_h	
15	Access No.	Transmission counter	58_h	
16	M2-Field	Manufacturer code	AE_h	
17	M2-Field	Manufacturer code	$0C_h$	
18	A2-Field	Serial No LSB (BCD)	66_h	
19	A2-Field	Serial No (BCD)	55_h	
20	A2-Field	Serial No (BCD)	44_h	
21	A2-Field	Serial No MSB (BCD)	33_h	
22	A2-Field	Version (or Generation number)	$0A_h$	

RSP-UD (wM-Bus)				
		wM-Bus frame	**BSHR -> COM**	
Byte No	**Field Name**	**Content**	**Bytes [hex]**	
23	A2-Field	Device type (Medium=COM)	31_h	
24	CI Field	Network Management Application	89_h	TPL
25	F-Field	Function Code	31_h	APL
26	SF-Field	Radio scan list, Control Information	05_h	
27	UNOL	Used Number Of Lines	00_h	
28	UNOL	0 lines used (Cleared with SND-UD)	00_h	
29	CRC 2			DLL
30	CRC 2			
31	MNOL	Maximum Number Of Lines	14_h	Application Layer
32	MNOL	Maximum 20 Lines	00_h	
33	AC	Active Columns	$3F_h$	
34	AC	ADD, RMD, TXI, RXT, LVL, STS	00_h	
35	LOAC 0	8 bytes for ADD	08_h	
36	LOAC 1	2 bytes for RMD	02_h	
37	LOAC 2	2 bytes for TXI	02_h	
38	LOAC 3	3 bytes for RXT	03_h	
39	LOAC 4	1 byte for LVL	01_h	
40	LOAC 5	1 byte for STS	01_h	
41	CRC 3			DLL
42	CRC 3			

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