

Electricity metering — Data exchange for meter reading, tariff and load control —

Part 31: Use of local area networks on twisted pair with carrier signalling

The European Standard EN 62056-31:2000 has the status of a
British Standard

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National foreword

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Summary of pages

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Part 31: Use of local area networks on twisted pair with carrier signalling
(IEC 62056-31:1999)

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données pour la lecture des compteurs,
le contrôle des tarifs et de la charge
Partie 31: Utilisation des réseaux locaux
sur paire torsadée avec signal de
porteuse
(CEI 62056-31:1999)

Messung der elektrischen Energie
Zählerstandsübertragung, Tarif- und
Laststeuerung
Teil 31: Nutzung örtlicher Bereichsnetze
mit Trägerfrequenz-Signalübertragung
auf verdrehten Zweidrahtleitungen
(IEC 62056-31:1999)

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European Committee for Electrotechnical Standardization
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Foreword

The text of document 13/1194/FDIS, future edition 1 of IEC 62056-31, prepared by IEC TC 13, Equipment for electrical energy measurement and load control, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 62056-31 on 1999-12-01.

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The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2000-10-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2002-12-01

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In this standard, annexes A to H and ZA are normative and annex I is informative.
Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 62056-31:1999 was approved by CENELEC as a European Standard without any modification.

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ELECTRICITY METERING – DATA EXCHANGE FOR METER READING, TARIFF AND LOAD CONTROL –

Part 31: Use of local area networks on twisted pair with carrier signalling

1 General

1.1 Scope

This part of IEC 62056 describes two new architectures for local bus data exchange with stations either energized or not. For non-energized stations, the bus supplies energy for data exchange.

The first architecture completes the base protocol (IEC 61142) with remote transfer services while the second one allows operation of DLMS services using the same physical medium and the same physical layer.

This complete compatibility guarantees the possibility of using IEC 61142 and IEC 62056-31 equipment on the same bus.

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 62056-51:1998, *Electricity metering – Data exchange for meter reading, tariff and load control – Part 51: Application layer protocols*

IEC 61334-4-41:1996, *Distribution automation using distribution line carrier systems – Part 4: Data communication protocols – Section 41: Application protocols – Distribution line message specification*

EIA 485: —, *Standard for Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems*

ISO/IEC 8482:1993, *Information technology – Telecommunications and information exchange between systems – Twisted pair multipoint interconnections*

2 General description

2.1 Basic vocabulary

All communication calls upon two systems called Primary Station and Secondary Station. The Primary Station is the system that decides to initialize a communication with a remote system called Secondary Station; these designations remain valid throughout the duration of the communication.

A communication is broken down into a certain number of transactions. Each transaction consists of a transmission from the Transmitter to the Receiver. During the sequence of transactions, the Primary Station and Secondary Station systems take turns to act as Transmitter and Receiver.

For the local bus data exchange architecture with DLMS, the terms Client and Server have the same meaning as for the DLMS model (refer to IEC 61334-4-41). The Server (which is a Secondary Station) acts as a VDE (refer to IEC 61334-4-41) for the submission of special service requests. The Client (which is a Primary Station) is the system that uses the Server for a specific purpose by means of one or more service requests.

2.2 Layers and protocols

The local bus data exchange architecture uses a breakdown into three network layers: *Physical*, *Data Link* and *Application*. The protocol corresponding to the *Physical* layer is the same for both local bus data exchange architecture, with and without DLMS, allowing all kinds of stations to be installed on the same bus.

The protocols corresponding to the *Data Link* and *Application* layers are defined in the table 1.

Table 1 – Architectures

	Layers	Protocols
Architecture	<i>Application</i>	<i>Application-62056-31</i>
Without DLMS	<i>Data Link</i>	<i>Link-62056-31</i>
Architecture	<i>Application</i>	<i>DLMS+ Application+ Transport+</i>
With DLMS	<i>Data Link</i>	<i>Link-E/D</i>

The *Transport+* and *Application+* protocols of the *Transport* and *Application* sub-layers of the *Application* layer are described in IEC 62056-51.

The *DLMS+* protocol of the *DLMS* sub-layer of the *Application* layer is described in IEC 61334-4-41.

2.3 Specification language

In this standard, the protocol of each layer is described by state transitions represented in the form of tables. The syntax used in making up these tables is defined by a specification language described in annex A.

In the event of a difference in interpretation between part of the text and a state transition table, the table is always taken as the reference.

2.4 Communication services for local bus data exchange without DLMS

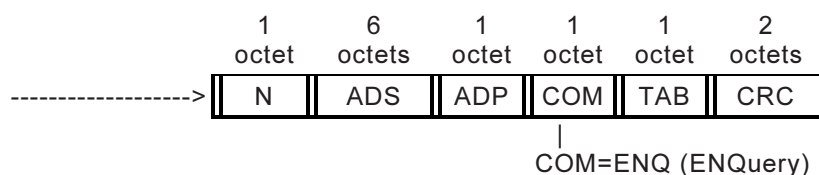
The list of available services is:

- a) remote reading of data;
- b) remote programming of data;
- c) point to point remote transfer, which is a simplified remote programming service;
- d) broadcast remote transfer;
- e) bus initialization;
- f) forgotten station call.

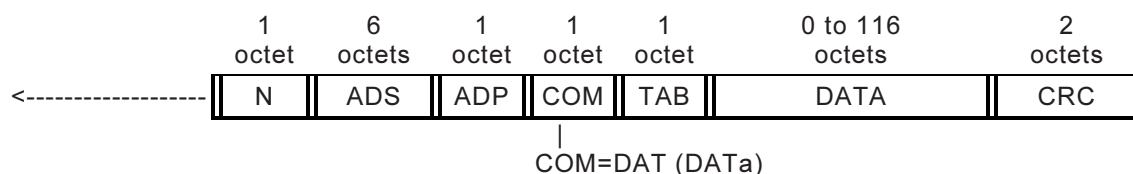
2.4.1 Remote reading exchange

The ENQ exchange consists of two frames arranged in one sequence:

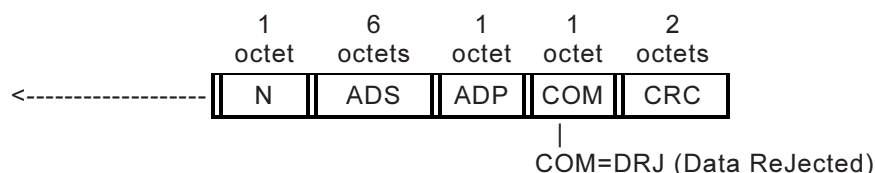
remote reading frame containing the type of data to select in the TAB field



positive acknowledgement frame with the selected data in the DATA field



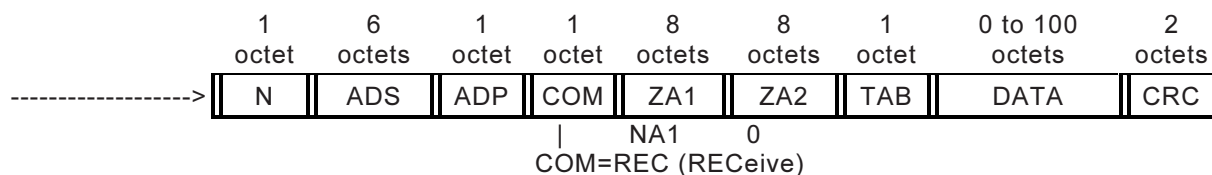
negative acknowledgement frame (TAB identifier unknown)



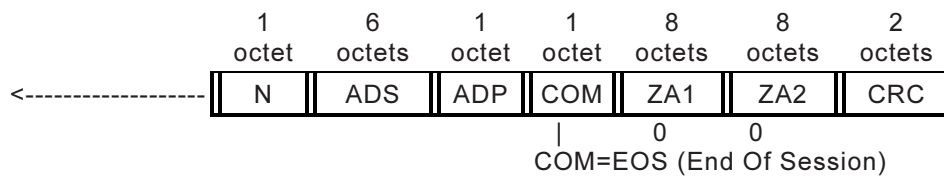
2.4.2 Remote programming exchange

The REC exchange consists of four frames arranged in two sequences. Since there is an internal sequence for authentication purpose, from the application point of view, it seems to be only one sequence with two frames:

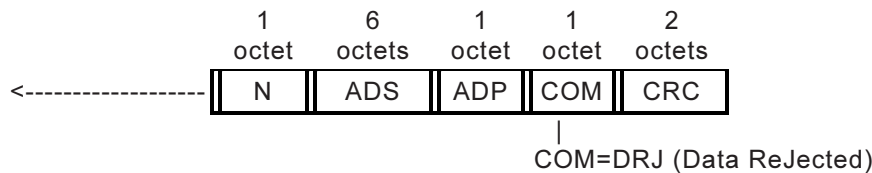
remote programming frame containing data in the DATA field and their type in the TAB field



positive acknowledgement frame (no authentication trouble)



negative acknowledgement frame (no authentication trouble but remote programming data not validated)



Authentication is carried out by an exchange of random numbers cyphered using a secret key specific to each Secondary Station. The random numbers are defined in 8 octets and they are ciphered with the DES algorithm using an 8-octet ciphering key K_i known both to the Primary and the Secondary station.

A random number NA1 is first generated by the Primary Station and transmitted into the ZA1 field of the remote programming frame while field ZA2 is set to zero.

On arrival at the Secondary Station, field ZA1 is ciphered by the DES algorithm with key K_i to get the ciphered random number NA1K. Then occurs the internal sequence for authentication which consists of two frames.

The first frame (from Secondary to Primary Station) contains this random number NA1K in field ZA1 and a random number NA2 generated by the Secondary station in field ZA2.

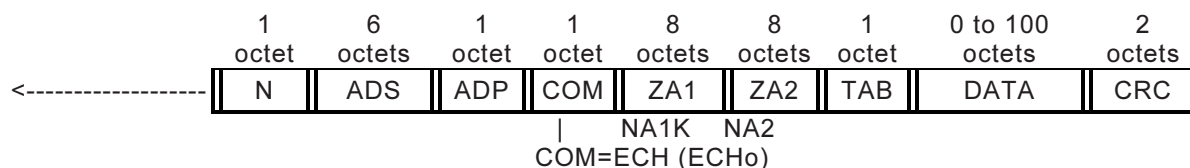
On reception of this frame, the Primary Station compares the ZA1 field to an NA1' number obtained by ciphering the transmitted NA1 number using the DES algorithm with key K_i . If $NA1' = ZA1$, then the Primary Station considers the called Secondary Station as authenticated. Otherwise, it considers the Secondary Station has not been authenticated and aborts the communication session.

After correct authentication of the Secondary Station, the Primary Station first ciphers the random number NA2 by the DES algorithm with key K_i to get the ciphered random number NA2K and then transmits it into field ZA2 while field ZA1 is set to zero.

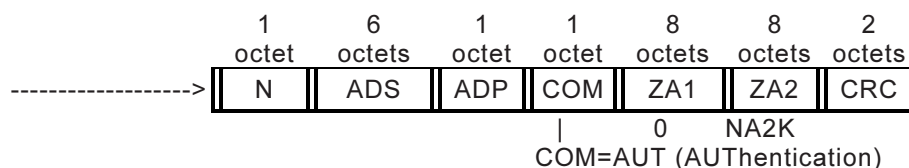
On reception of this response frame, the Secondary Station compares the ZA2 field to an NA2' number obtained by ciphering the transmitted NA2 number using the DES algorithm with key K_i . If $NA2' = ZA2$, then the Secondary Station considers the Primary Station as authenticated. Otherwise, it considers the Primary Station has not been authenticated and sends a negative acknowledgment frame.

The internal authentication exchange is the following:

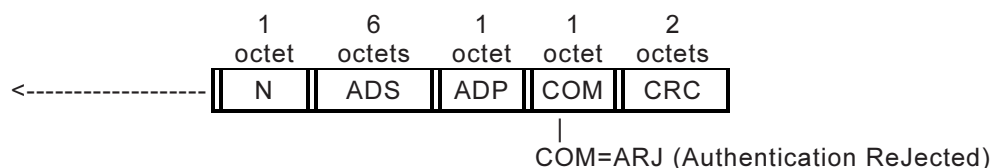
internal authentication frame containing the ciphered random number NA1K in field ZA1 and the random number NA2 in field ZA2



positive response frame containing the ciphered random number NA2K in field ZA2 (if the Secondary Station is considered as authenticated)



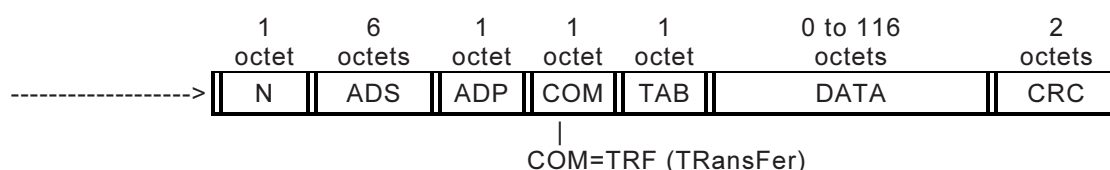
an authentication rejection frame replaces the normal EOS or DRJ frame when the Primary Station is not considered authenticated



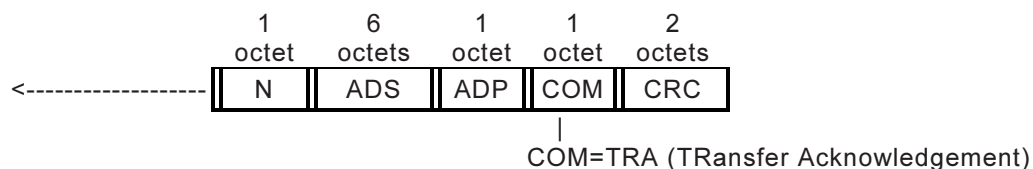
2.4.3 Point to point remote transfer exchange

This TRF exchange consists of two frames arranged in one sequence. From the application point of view, it seems to be a remote programming exchange in a single sequence with no authentication:

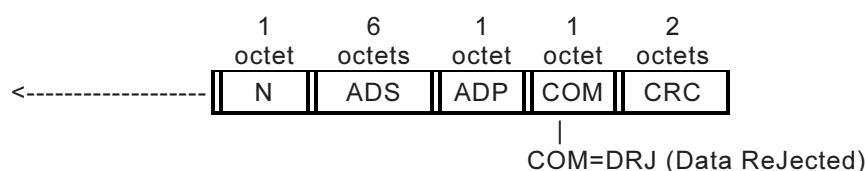
point to point remote transfer frame containing data in the DATA field and their type in the TAB field



positive acknowledgement frame



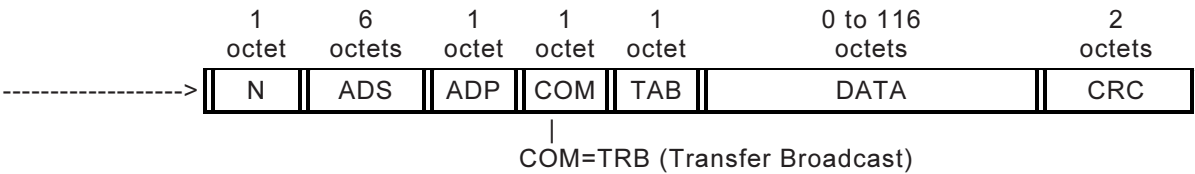
negative acknowledgement frame (remote transfer data not validated)



2.4.4 Broadcast remote transfer frame

This TRB frame does not involve any frame answer. From the application point of view, it seems to be a point to point remote transfer, but without acknowledgement since it is a broadcasting:

broadcast remote transfer frame containing data in the DATA field and their type in the TAB field

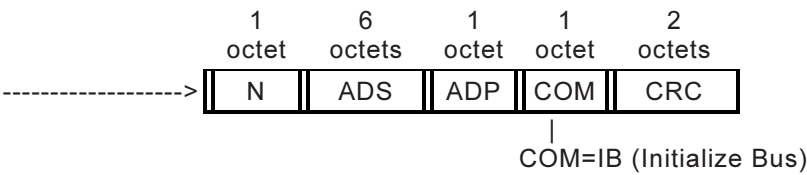


The secondary address (which defines the receiving Secondary Stations) shall be a broadcast address.

2.4.5 Bus initialization frame

This IB frame does not involve any frame answer. From the application point of view, it seems to be a broadcast remote transfer, but without data since its purpose is only to reset a special flag (called forgotten station flag) to TRUE for all Secondary Stations that have been programmed with the ADP address:

bus initialization frame



The secondary address (which defines the receiving Secondary Stations) shall be a broadcast address.

After the bus initialization frame, any Secondary Station receiving a correct ENQ frame containing a known TAB identifier will then no longer be considered as a “forgotten station”.

2.4.6 Forgotten station call exchange

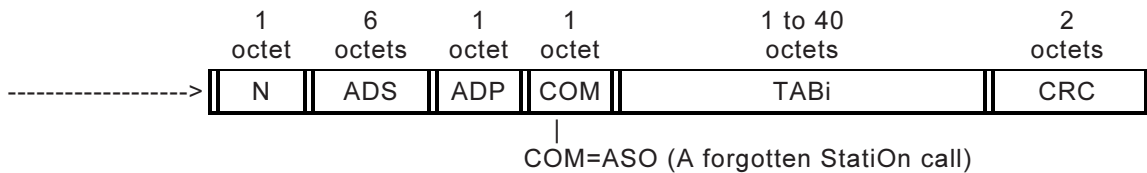
This ASO exchange consists of two frames arranged in one sequence. At the end of a remote reading sequence, the Primary Station can search for stations whose forgotten station flag is TRUE (maximum 5 in 100).

As a correct remote reading exchange sets the forgotten station flag of the corresponding station to FALSE, the ASO exchange normally occurs after the completion of a remote reading sequence that is one or several remote reading exchanges preceded by a bus initialization frame.

The Primary Station manages several time slots. When detecting a collision, it has to retry an ASO exchange. Nevertheless, each time a correct Secondary Station answer is received, the Primary Station shall eliminate it from the list of forgotten stations by operating a correct remote reading exchange with this station.

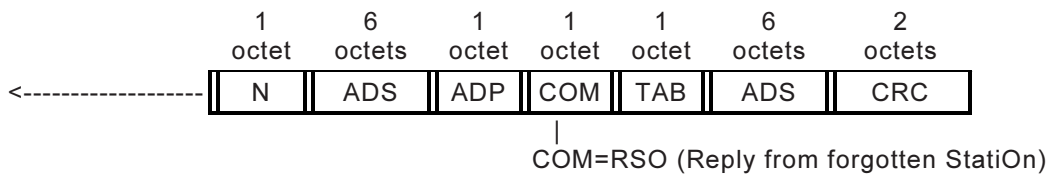
In order to assure the selection constraints (described in 2.4.9), the non-energized stations shall answer in the first time slot of the first ASO exchange. Then, only the forgotten stations are selected and the usual principle can be used for the following ASO exchanges.

forgotten station call frame containing selection criteria in the TABi field (1 to 40 TAB identifiers)



The secondary address (which defines the receiving Secondary Stations) should be a broadcast address.

acknowledgement frame containing the first TAB recognized by the unit and the ADS of the station



2.4.7 Frame fields

- N total number of octets in the frame, including N.
- ADS absolute physical address of the Secondary Station coded as a 48-bit string. There is only one broadcast physical address which is the general broadcast ADG coded as "000000000000" in hexadecimal ¹⁾ The ADS also corresponds exactly to the System Title of the Secondary Station.
- ADP physical address of the Primary Station coded as an 8-bit string. The value "00"H is reserved for the coding of the physical address of the general primary APG ²⁾. Any Secondary Station solicited by a Primary Station whose physical address is APG, replies with the first primary physical address with which it has been programmed
- COM command code depending on the exchange and the frame direction (see annex D)
- ZA1, ZA2 fields reserved for authentication operated during the remote programming exchange
- TAB type of data selected associated with some command codes (ENQ, DAT, REC, TRF, TRB or RSO). The value "00"H is reserved for systems management, the value "FF"H for alarm management.
- DATA information packet from the host application. This field can be eventually empty depending on the command code.
- CRC Cyclic Redundancy Check field corresponds to the 16 redundant bits of the CRC whose principle is described in annex E.

1) Other broadcast addresses could be defined depending on the naming rules adopted in companion standards for the semantics of the System Titles which are often based on a manufacturer code, a manufacture year and an equipment type.

2) Other general addresses could be defined depending on the naming rules adopted in companion standards for the semantics of operator identifiers which are often based on a utility code.

The frame fields are transmitted in an ascending order (from N to CRC). When a field contains data over several octets, the transmission begins with the least significant octet and ends with the most significant one. However, the DATA field is considered as an octet string and transmitted in an ascending order.

2.4.8 Principle of the energy remote supply

The general principle of the data exchanges is preserved for the non-energized stations. The notion of energy remote supply is only added for communication between a Primary Station and one or more Secondary Stations.

To begin a communication session, the Primary Station should send a "Wakeup Call" designed to alert the communications system of every Secondary Station connected to the bus. This call is a continuous carrier for a nominal time depending on the energy remote supply mechanism:

- the "Wakeup Call" signal duration is AGT to wake up non-energized stations;
- the "Wakeup Call" signal duration is AGN to wake up energized stations.

Remark: A Secondary Station can be configured in Alarm mode. It is then remote supplied continuously and so can transmit the alarm to the Primary Station (see 2.4.11).

Then, whatever type of remote station is selected (energized or not), an intermediate AGN "Wakeup Call" signal shall also be required at the Primary Station side in the following circumstances:

- before the first ENQ or TRF exchange;
- before the sixth consecutive and successful ENQ or TRF exchange with the same Secondary Station;
- before the first ENQ or TRF exchange with a different Secondary Station to the one previously selected in the preceding ENQ or TRF exchange;
- before any REC exchange;
- before any TRB frame;
- before any IB frame;
- before any ASO exchange.

For non-energized stations, it means that the Primary Station can avoid to wake up all the remote stations when not necessary, and then save its energy.

A Primary Station can use a specific modem ensuring both the energy remote supply as well as the modulation and demodulation functions. The communication time and the number of non-energized stations shall be optimized in order to save the battery of the Primary Station.

As another possibility, the Primary Station might only focus on the modulation and demodulation functions. In this case, an auxiliary station continuously supplies the bus with energy.

A Secondary Station generally contains only one logical application referenced by its ADS. Such a station may or may not be energized.

A multiple Secondary Station (containing several logical applications corresponding to several ADSs) should be a non-energized station. This feature is described more fully in clause 5.

2.4.9 Non-energized station preselection exchange

To optimize the bus consumption, a preselection exchange enables the Primary Station to select a non-energized Secondary Station.

The preselection exchange occurs after an AGT "Wakeup Call" signal addressed to all non-energized stations of the bus. To limit the bus consumption, the first frame sent by the Primary Station should be short enough and the addressed Secondary Station should answer before the triggering of the TOPRE wakeup. Not seeing an answer in time, the modem of the Secondary Station goes back in a low consumption state.

During the preselection exchange, all the non-energized stations consume energy. The bus voltage and the energy storage capacitors decrease until the non selected stations goes back in a low consumption state. Then the continuously sent energy charges the energy storage capacitors and the bus voltage increase.

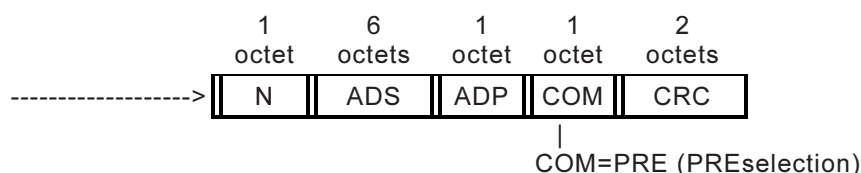
The modem of the Primary Station should store sufficient energy before the first preselection. This step is guaranteed by a wait-time controlled thanks to the TICB wakeup. At the end of a preselection, the energy storage capacitors are empty and the Primary Station shall wait for the bus voltage increase before a second preselection.

As the preselection frame shall not be more than 18 bytes long, it can be

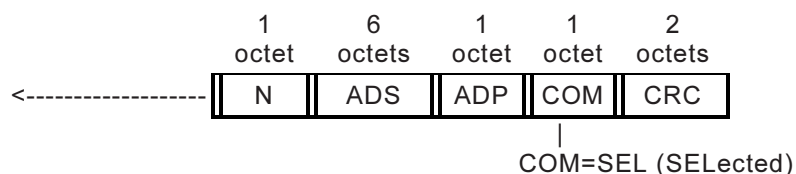
- an ENQ frame;
- a TRB or TRF frame, if and only if the data field is less than or equal to 6 octets long;
- an IB frame;
- an ASO frame, if and only if the number of TABi fields is less than or equal to 7.

As the first frame of REC and TRF exchanges may be too long, an additional service is provided for preselection. This fully transparent PRE exchange consists of two frames arranged in one sequence.

non-energized station preselection frame



acknowledgement frame



To save the energy of the Primary Station, there is no retry during a preselection exchange. If an addressed non-energized station does not answer correctly, it is not selected and the Primary Station shall send a new AGT "Wakeup Call" signal.

2.4.10 Communication exchange after preselection

After preselection, the modem of a non-energized station can stay awake for the continuing communication and delays are not critical since the number of connected devices is limited. The Primary Station supplies the selected station and charges the capacitive reservoirs of the non-selected stations.

The normal end of the communication session occurs differently depending on the energy remote supply mechanism:

- after a short period of inactivity during the communication session when no intermediate AGN “Wakeup Call” signal is required for energized stations. This period is checked by the wakeup TOL;
- after a longer period of inactivity during the communication session for non-energized stations. This period is checked by the wakeup TOAG.

Note that for a non-energized station, as far as there is no timeout of TOAG wakeup, an intermediate AGN “Wakeup Call” signal is enough to go on the current communication session.

2.4.11 Alarm function

A device integrated in a simple or multiple Secondary Station (see 5.2.3) can transmit alarms to the primary station, providing it can integrate functions of interface as described hereafter.

An alarm shall be fetched from the Secondary Station in 10 s maximum.

A programmable configuration on the Interface and one on each device selects the status of Alarm mode: Active or Inactive.

When Alarm mode is active, the device can generate an alarm, inside the secondary station. The Alarm function is effective only if the supply is present and permanent on the bus.

The device sends the alarm during TASB. TASB is long enough to force an “0” state on the secondary bus and to be detected by the Interface, even if a communication is in progress.

Alarm mechanism is described in the figure 1.

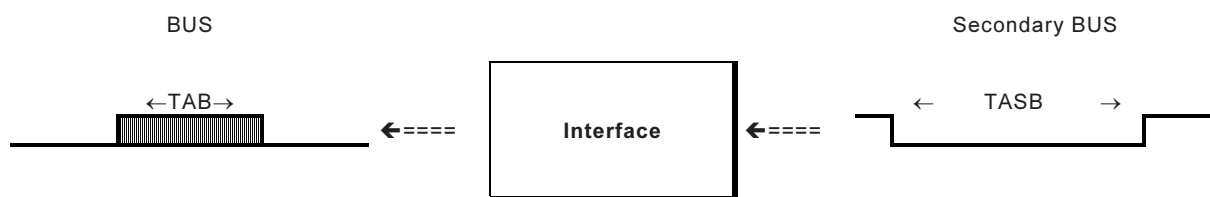


Figure 1 – Alarm mechanism

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The alarm is not directly transmitted towards the primary station. The interface receives the alarm and transmits it by sending a “0” (50 kHz carrier) during TAB on the bus when it is possible:

a) No communication on the bus

When the interface receives the alarm on the secondary bus, it transmits it on the bus.

b) On synchronization of AGN or AGT when a communication is in progress. When a communication is in progress on the bus, the Interface memorises the alarm received. It transmits it to the bus after one of the following events:

- TOALR after the end of AGN or AGT reception,
- when the normal end of the communication session occurs.

In this way, the interface can filter the alarm to avoid conflict on the bus.

After the alarm generation, the Secondary Station will be considered as a "forgotten station" with a selection criteria equal to FF.

The primary station configured in Alarm mode listens to the bus when there is no communication on the bus and after transmission of an AGN or AGT in order to detect an alarm. When the primary station receives an alarm, it enters in Forgotten Station Call procedure with a selection criteria in the TABi field equal to FF (see 2.4.6).

Timing diagrams explain Alarm management in 3.1.3.

2.5 Communication services for local bus data exchange with DLMS

DLMS does not offer services to operate the bus initialization and forgotten station call mechanisms. Nevertheless, the IB frame and the ASO exchange are supported and managed as they are with the local bus data exchange architecture without DLMS except that the forgotten station flag is considered as a global variable shared with the Application Programming Interface.

Remote reading of data and point to point remote transfer are directly foreseen by DLMS. But the (redundant) remote programming of data is not supported since authentication is reserved for the *Application* layer.

As data semantics is managed by DLMS, the frame format is very simple and only unmarked frames are required. To ensure compatibility with the architecture without DLMS, this frame format is defined by the following nine fields:

1 octet	6 octets	1 octet	3 bits	1 bit	2 bits	2 bits	0 to 117 octets	2 octets
Size	ADS	ADP	DATA+	Priority	Send	Confirm	Text	CRC

Size total number of octets in the frame, including Size. If its value is not 11, the Receiver knows that the frame contains data in the Text field

ADS same rules as for local bus architecture without DLMS

ADP same rules as for local bus architecture without DLMS

DATA+ always coded "111"B

Priority transmission priority level of the current frame. The *Application* layer sets this priority according to the requested service

Send number of the last frame sent

Confirm number of the last frame received without error

- Text DSDU (Data link Service Data Unit) from the higher level. A frame does not necessarily contain text. If data from the *Application* layer is available when the frame is sent, then the *Text* field will contain data, otherwise it will be empty. This mechanism provides the conditions for balanced bi-directional data transmission. In order not to confuse DATA+ frame with frames from the architecture without DLMS, the DATA+, Priority, Send and Confirm fields make up a special command code COM whose values shall be different from the already reserved COM values (see annex D)
- CRC same rules as for local bus architecture without DLMS

The frame fields are transmitted in ascending order (from Size to CRC). When a field is coded on several octets, the transmission begins with the least significant octet and ends with the most significant one. However, the Text field is considered as an octet string and transmitted in ascending order.

2.6 Systems management

The purpose of Systems management is to make an enrolment which includes an identification of Secondary Stations on a bus. For that aim, it provides the Discover service.

The enrolment consists of a sequence of Discover requests issued by the active initiator located inside the Primary Station. Each Discover service is provided to inform the remaining new stations that they will have a chance to respond in the next time slots.

A Discover request conveys a specific response-probability argument as an integer in the range [0, 100]. It expresses the probability, in per cent, that a new station responds. When it is set to 100, all the new stations on the bus shall respond.

On reception of a Discover indication, each Secondary Station tests the value of its flag Discovered. If it is set to TRUE, the indication is discarded else it draws a random number between 1 and 100. If this number is smaller than or equal to the response-probability argument, the new station will issue a Discover response and set its flag Discovered to TRUE.

The flag Discovered is always reset by an IB frame.

To ensure a maximum compatibility (for stations including DLMS or not), it is proposed to implement the systems management as indicated in annex H.

3 Local bus data exchange without DLMS

3.1 Physical layer

3.1.1 Physical-62056-31 protocol

The *Physical-62056-31* protocol of the *Physical* layer of the local bus data exchange architecture without DLMS behaves asymmetrically. The state machine of the Primary Station is therefore different from that of the Secondary Station.

The *Physical-62056-31* protocol supports the Secondary Stations whether or not they are energized. As already stated in the general description, the remote stations shall be woken up either by an AGN or an AGT "Wakeup Call" signal and a communication session ends after expiry of TOL or TOAG wakeup.

After a "Wakeup Call" signal, a communication session is then made asynchronously and by half-duplex at 1 200 bits/s on the bus.

3.1.2 Physical parameters

The value of the maximum size of a frame being received, MaxIndex, is set to 128.

The value of the maximum number of RSO time slots for the processing of a “Forgotten Stations Call”, MaxRSO, is set to 3.

The AGN duration of an AGN “Wakeup Call” signal shall be in the range [50, 150[ms, while the AGT duration of an AGT “Wakeup Call” signal shall be in the range [200, 300[ms.

Timing type and characteristics are described in annex B.

The values of the table 2 are defined for a Primary Station.

Table 2 – Primary station timing

	Min. ms	Nominal ms	Max. ms	Type	Definition
TA1O	–	–	120	TSL1	Maximum waiting period of the first octet of a frame being received
TAB		100		Tc	Duration of an alarm signal on the bus
TAGN	–	100	–	TPDF	Duration of an AGN “Wakeup Call” signal
TAO	–	–	40	Tc	Maximum waiting period of one octet of a frame being received whose expiry indicates the end of a frame
TARSO	–	500	–	Tc	Length of an RSO time slot
TASB		1 200		Tc	Waiting period after the beginning of an alarm signal
TEMPO	–	40	–	Tc	Safety delay at the end of transmission of a Wake up signal or a frame
TOE	–	–	1 100	TL	Safety delay for transmitting to protect against defective hardware
TOL	–	–	100	TSL2	Maximum waiting time for a request coming from the upper layer
Non-energized station Specific (Supply)					
TAGT	–	250	–	TPDF	Duration of an AGT “Wakeup Call” signal
TICB	8 000	–	–	Ta	Initial bus charge period
TOAG	–	–	3 000	TPFD	Maximum delay for a selected non-energized station to recognize an AGN “Wakeup Call” signal

The values of table 3 are defined for a Secondary Station.

Table 3 – Secondary station timing

	Min. ms	Nominal ms	Max. ms	Type	Definition
TA1O	30 ¹⁾	–	160	TSL1	Maximum waiting period of the first octet of a frame being received
TAB		100	–	TC	Duration of an alarm signal on the bus
TAGN	50	100	150	TPDF	Duration of an AGN “Wakeup Call” signal
TAO	–	–	40	TC	Maximum waiting period of one octet of a frame being received whose expiry indicates the end of a frame
TARSO	–	–	500	TC	Length of an RSO time slot
TOALR	20	–	–	TL	Waiting to send an AGN after an AGN or AGT reception
TOE	–	–	1 100	TL	Safety delay for transmitting to protect against defective hardware
TOL	–	–	100	TSL2	Maximum waiting time for a request coming from the upper layer
Non-energized station Specific (Supply)					
TAGT	200	250	300	TPDF	Duration of an AGT “Wakeup Call” signal
TASB	–	1200	–	TL	Duration of a secondary-bus alarm signal
TICB	8 000	–	–	Ta	Initial bus charge period
TOAG	–	–	3000	TPFD	Maximum delay for a selected non-energized station to recognize an AGN “Wakeup Call” signal
TOAGN	–	–	300	Tc	Maximum delay of inactivity to recognize the end of a communication session with an energized station
TOAPPEL	–	–	180	TPFD	Maximum waiting period of the first octet of a preselection frame being received
TOBAVAR D	–	–	260	TPDF	Safety delay to protect against defective length of preselection frame
TOPRE	–	–	130	TPFD	Maximum waiting for a preselection answer
TOSEUIL	–	150	–	TC	Duration of a “Wakeup Call” signal which wakes up a non-energized station
TVASB	40	–	–	TL	Minimum duration of an alarm signal on the secondary bus

¹⁾ After a “Wakeup Call”, a minimum duration of 30 ms is necessary.

3.1.3 Timing diagrams

The figures 2, 3 and 4 can be used to show different types of session of the protocol for non-energized secondary stations.

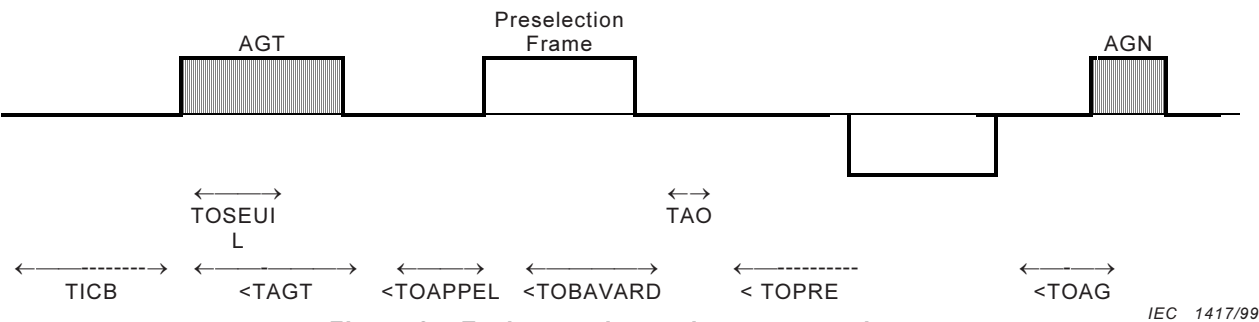


Figure 2 – Exchanges in continuous operation

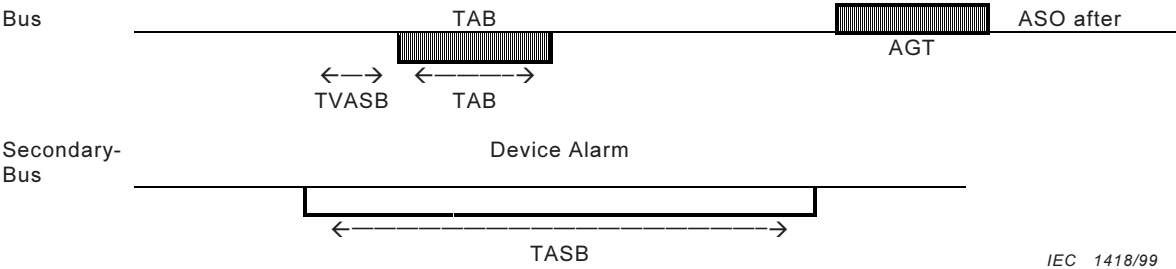


Figure 3 – Alarm event without any communication in progress

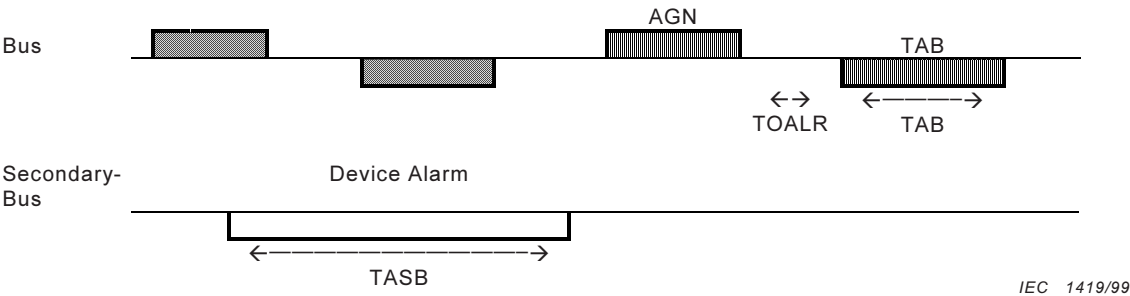


Figure 4 – Alarm event with a communication in progress

3.1.4 Physical services and service primitives

The user of the *Physical-62056-31* protocol can use the services and service primitives given in the table 4.

Table 4 – Physical services and service primitives

Service	Service primitive
Phy_DATA	Phy_DATA.req(Frame) Phy_DATA.ind(Frame)
Phy_UNACK	Phy_UNACK.req(Frame)
Phy_APPG	Phy_APPG.req(TypeAG) Phy_APPG.ind()
Phy_ASO	Phy_ASO.req(Frame) Phy_ASO.ind(Frame)
Phy_RSO	Phy_RSO.req(Frame, Window)
Phy_COLL	Phy_COLL.ind()
Phy_ALARM	Phy_ALARM.req() Phy_ALARM.ind()
Phy_ABORT	Phy_ABORT.req() Phy_ABORT.ind(ErrorNb)

The role assigned to each primitive is as follows:

- Phy_DATA.req(Frame) enables the *Data Link* layer to request the *Physical* layer to transmit a frame Frame;
- Phy_DATA.ind(Frame) enables the *Physical* layer to inform the *Data Link* layer that a frame Frame is available;
- Phy_UNACK.req(Frame) enables the *Data Link* layer to request the *Physical* layer to transmit a frame Frame without waiting for acknowledgement;
- Phy_APPG.req(TypeAG) enables the *Data Link* layer to request the *Physical* layer to transmit a “Wakeup Call” signal. The duration TypeAG of this signal is either AGN or AGT;
- Phy_APPG.ind() enables the *Physical* layer to inform the *Data Link* layer of the end of the transmission of a “Wakeup Call” signal;
- Phy_ASO.req(Frame) enables the *Data Link* layer to request the *Physical* layer to transmit a “Forgotten Stations Call” frame;
- Phy_ASO.ind(Frame) enables the *Physical* layer to inform the *Data Link* layer that a frame Frame has been received in one of the time slots of the forgotten stations;
- Phy_RSO.req(Frame, Window) enables the *Data Link* layer to request the *Physical* layer to transmit a Forgotten Stations Call frame Frame in the time slot number Window;
- Phy_COLL.ind() enables the *Physical* layer to inform the *Data Link* layer that a collision has been detected in one of the time slots of the forgotten stations;
- Phy_ALARM.req() enables the *Data Link* layer to request the *Physical* layer to transmit an Alarm;
- Phy_ALARM.ind() enables the *Physical* layer to inform the *Data Link* layer of the arrival of an alarm;
- Phy_ABORT.req() enables the *Data Link* layer to request the *Physical* layer to end its activity;
- Phy_ABORT.ind(ErrorNb) enables the *Physical* layer to inform the *Data Link* layer of the occurrence of a fatal error identified by the number ErrorNb.

3.1.5 State transitions

Table 5 – *Physical-62056-31* state transitions: Primary Station

Initial state	Triggering condition	Set of actions	Final state
<i>Initial</i>	\$true()	MaxRSO=3 MaxIndex=128 Collision=FALSE SessionAGT=FALSE wait_time(TICB)	Stopped
Stopped	Phy_APPG.req(AG) & AG=AGN	stop_timer(TOAG) FlagAbort=FALSE TypeAG=AGN send_AG(TypeAG)	W.AG
Stopped	Phy_APPG.req(AG) & AG=AGT	SessionAGT=TRUE FlagAbort=FALSE TypeAG=AGT send_AG(TypeAG)	W.AG
Stopped	time_out(TOAG)	Phy_ABORT.ind(EP-2) SessionAGT=FALSE	Stopped
Stopped	Phy_ABORT.req()	\$none()	Stopped
Stopped	data-carrier_on	init_timer(TAB) init_timer (TASB)	W.ETABS
W.ETABS	data_carrier_off	stop_timer(TASB) stop_timer(TAB)	Stopped
W.ETABS	time_out(TAB)	Phy_ABORT.ind(EP-3) Phy_ALARM.ind()	W.TASB
W.AG	AG_sent_event	Phy_APPG.ind() init_timer(TEMPO)	W.TAB
W.AG	Phy_ABORT.req()	FlagAbort=TRUE	W.AG
W.TAB	data-carrier_on	Carrier = TRUE init_timer(TAB) init_timer (TASB)	W.TAB
W.TAB	data-carrier_off	Carrier = FALSE stop_timer(TAB) stop_timer (TASB)	W.TAB
W.TAB	time_out(TEMPO) & not(FlagAbort) & not(Carrier)	init_timer(TOL)	M.Send
W.TAB	time_out(TEMPO) & FlagAbort & not(Carrier)	wait_time (TOL)	<i>T.Session</i>
W.TAB	time_out(TEMPO) & Carrier	init_timer(TOL)	W.ETAB
W.TAB	Phy_ABORT.req()	FlagAbort=TRUE	W.TAB

W.ETAB	time_out(TAB)	Phy_ABORT.ind(EP-3) Phy_ALARM.ind() stop_timer(TOL)	W.TASB
W.ETAB	data_carrier_off & not(FlagAbort)	stop_timer(TAB) stop_timer (TASB)	M.Send
W.ETAB	data_carrier_off & FlagAbort	stop_timer(TAB) stop_timer (TASB)	W.TOL
W.ETAB	Phy_ABORT.req()	FlagAbort=TRUE	W.ETAB
W.TASB	time_out(TASB)	\$none()	Stopped
W.TOL	time_out(TOL)	\$none()	<i>T.Session</i>
M.Send	Phy_DATA.req(Frame)	Service=NORMAL	<i>SendFirst</i>
M.Send	Phy_UNACK.req(Frame)	Service=UNACKNOWLEDGED	<i>SendFirst</i>
M.Send	Phy_ASO.req(Frame)	Service=ASO	<i>SendFirst</i>
M.Send	Phy_ABORT.req()	\$none()	M.Send
M.Send	time_out(TOL)	\$none()	<i>T.Session</i>
<i>T.Session</i>	SessionAGT=TRUE	init_timer(TOAG) Phy_ABORT.ind(EP-1) wait_time(TEMPO)	Stopped
<i>T.Session</i>	SessionAGT=FALSE	Phy_ABORT.ind(EP-1) wait_time(TEMP0)	Stopped
<i>SendFirst</i>	\$true()	stop_timer(TOL) Size=size(Frame) Index=1 send_octet(Frame, Index) Size=Size-1 init_timer(TOE)	Sending
Sending	octet_sent_event & Size>0	Index=Index+1 send_octet(Frame, Index) Size=Size-1	Sending
Sending	octet_sent_event & Size=0	stop_timer(TOE) wait_time(TAO) Index=1 Frame=""	<i>Answer</i>
Sending	Phy_ABORT.req()	stop_timer(TOE) wait_time(TAO) init_timer(TA1O) FlagAbort=TRUE	M.Rec
Sending	time_out(TOE)	Phy_ABORT.ind(EP-3F) wait_time(TAO) init_timer(TA1O) FlagAbort=TRUE	M.Rec
<i>Answer</i>	Service=NORMAL I Service=UNACKNOWLEDGED	init_timer(TA1O)	M.Rec
<i>Answer</i>	Service=ASO	WinRSO=1 init_timer(TARSO) init_timer(TA1O)	M.Rec

M.Rec	octet_received_event	stop_timer(TA1O) Index=Index+1 read_data(RecB) concat(Frame, RecB) init_timer(TAO)	Receiving
M.Rec	collision_detected_event	stop_timer(TA1O) Collision=TRUE init_timer(TAO)	Receiving
M.Rec	time_out(TA1O)	\$none()	Received
M.Rec	Phy_ABORT.req()	FlagAbort=TRUE	M.Rec
Receiving	octet_received_event & Index<=MaxIndex	stop_timer(TAO) Index=Index+1 read_data(RecB) concat(Frame, RecB) init_timer(TAO)	Receiving
Receiving	octet_received_event & Index>MaxIndex	Phy_ABORT.ind(EP-4F) wait_time(TAO) FlagAbort=TRUE	Received
Receiving	collision_detected_event	stop_timer(TAO) Collision=TRUE init_timer(TAO)	Receiving
Receiving	time_out(TAO)	\$none()	Received
Receiving	time_out(TARSO)	Phy_ABORT.ind(EP-5F) wait_time(TAO) FlagAbort=TRUE	Received
Receiving	Phy_ABORT.req()	Flagabort = TRUE	Receiving
Received	Service=NORMAL & not(Flagabort)	Phy_DATA.ind(Frame) init_timer(TOL)	M.Send
Received	(Service=NORMAL & Flagabort) Service=UNACKNOWLEDGED	wait_time(TOL)	T.Session
Received	Service=ASO & Collision & not(Flagabort)	Phy_COLL.ind() Collision=FALSE	T.RSO
Received	Service=ASO & not(Collision) & not(Flagabort)	Phy_ASO.ind(Frame)	T.RSO
Received	Service=ASO & Flagabort	\$none()	T.RSO
T.RSO	(TypeAG=AGT) (WinRSO>=MaxRSO) & (TypeAG=AGN)	stop_timer(TARSO)	T.Session
T.RSO	(WinRSO<MaxRSO) & (TypeAG=AGN)	Index=1 Frame=""	W.RSO
W.RSO	time_out(TARSO)	WinRSO=WinRSO+1 init_timer(TARSO) init_timer(TA1O)	M.Rec
W.RSO	Phy_ABORT.req()	Flagabort=TRUE	W.RSO

**Table 6 – Power supply management state transitions
(only for non-energized Secondary Station)**

Initial state	Triggering condition	Set of actions	Final state
<i>Initial</i>	alarm_detection()	Flagalarm = TRUE FlagSendAlarm = FALSE station_power(ON)	Stopped
<i>Initial</i>	not(alarm_detection())	Flagalarm = FALSE	Stopped
Stopped	occur(cpt_carrier_on) & Flagalarm	init_timer(TVASB)	W.TVASB2
Stopped	occur(data_carrier_on)	init_timer(TOSEUIL) init_timer(TAGT)	W.TOSEUIL
W.TOSEUIL	time_out(TOSEUIL) & not(Flagalarm)	station_power(ON)	W.AGT
W.TOSEUIL	occur(data_carrier_off) & not(Flagalarm)	stop_timer(TOSEUIL) stop_timer(TAGT)	Stopped
W.TOSEUIL	time_out(TOSEUIL) & Flagalarm	station_signal(ON) Tend = TOAG	W.AGT
W.TOSEUIL	occur(data_carrier_off) & Flagalarm	stop_timer(TOSEUIL) stop_timer(TAGT) Tend = TOAGN init_timer(Tend)	Hide
W.TOSEUIL	occur(cpt_carrier_on) & Flagalarm	init_timer(TVASB)	W.TVASB1
W.AGT	occur(data_carrier_off)	stop_timer(TAGT) init_timer(TOAPPEL)	W.Sel
W.AGT	time_out(TAGT) & not(Flagalarm)	station_power(OFF)	Stopped
W.AGT	time_out(TAGT) & Flagalarm	init_timer(Tend)	Hide
W.Sel	occur(octet_received_event)	stop_timer(TOAPPEL) init_timer(TOBAVARD) init_timer(TAO)	Select
W.Sel	time_out(TOAPPEL) & not(Flagalarm)	station_power(OFF)	Stopped
W.Sel	time_out(TOAPPEL) & Flagalarm	station_signal(OFF)	Stopped
W.Sel	occur(cpt_carrier_on) & Flagalarm & not(FlagSendalarm)	init_timer(TVASB)	W.TVASB1
Select	occur(octet_received_event)	stop_timer(TAO) init_timer(TAO)	Select
Select	time_out(TAO)	stop_timer(TOBAVARD) init_timer(TOPRE)	W.Answer

Select	time_out(TOBAVARD) & not(Flagalarm)	stop_timer(TAO) station_power(OFF)	Stopped
Select	time_out(TOBAVARD) & Flagalarm	stop_timer(TAO) init_timer(Tend)	Hide
W.Answer	occur(octet_sent_event)	stop_timer(TOPRE) init_timer(Tend)	Hide
W.Answer	time_out(TOPRE) & not(Flagalarm)	station_power(OFF)	Stopped
W.Answer	time_out(TOPRE) & Flagalarm	init_timer(Tend)	Hide
W.Answer	occur(cpt_carrier_on) & Flagalarm & not(FlagSendAlarm)	init_timer(TVASB)	W.TVASB1
Hide	occur(octet_received_event) occur(octet_sent_event) (occur(data_carrier_on) & not(FlagSendAlarm))	stop_timer(Tend) init_timer(Tend)	Hide
Hide	occur(data_carrier_on) & FlagSendAlarm	stop_timer(Tend)	W.AGend
Hide	time_out(Tend) & not(Flagalarm)	station_power(OFF)	Stopped
Hide	time_out(Tend) & Flagalarm & not(FlagSendAlarm)	station_signal(OFF)	Stopped
Hide	time_out(Tend) & Flagalarm & FlagSendAlarm	Send_AG(AGN)	W.AB
Hide	occur(cpt_carrier_on) & Flagalarm & not(FlagSendAlarm)	init_timer(TVASB)	W.TVASB1
W.AGend	occur(data_carrier_off)	wait_time(TOALR) Send_AG(AGN)	W.AB
W.TVASB1	occur(cpt_carrier_off)	stop_timer(TVASB) init_timer(Tend)	Hide
W.TVASB1	time_out(TVASB)	FlagSendAlarm = TRUE init_timer(Tend)	Hide
W.TVASB1	time_out(Tend)	\$none()	W.TVASB2
W.TVASB2	occur(cpt_carrier_off)	stop_timer(TVASB) station_signal(OFF)	Stopped
W.TVASB2	occur(data_carrier_on)	\$none()	W.TVASB1
W.TVASB2	time_out(TVASB)	Send_AG(AGN)	W.AB
W.AB	AG_sent_event	FlagSendAlarm = FALSE station_signal(OFF)	Stopped