EIBA Handbook Series

Release 3.0

Volume 3:
System Specifications

Part 2: Medium Dependent Layers

Chapter 1: EIB Implementation on Twisted Pair

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1. Physical Layer Type Twisted Pair (PhL TP64 & TP256)

The physical layer described in this clause is called physical layer type twisted pair TP64 and twisted pair TP256. The main differences are shown in table of Fig. 3/2/1-1. TP256 is backward compatible towards TP64. If common features of TP64 and TP256 are described, only the expression TP is used.

EIB's twisted pair medium TP characteristics are

- data and power transmission with one wire pair
- asynchronous character-oriented data transfer
- half duplex bi-directional communication
- an EIB-specific balanced baseband signal coding under SELV conditions

All the characteristics given in the following sub-clauses, like maximum number of EIB End Devices (EED's) or possible cable length per physical segment are only valid for the standardized bus cable and standard EED's[1]. These characteristics may be different if other bus cables (e.g. with other core diameters) or other EED’s are used. For information on standardized cables, connectors, power supply and choke refer to Part 9/1 "Cables and Connectors" respectively Part 9/2 "Basic Components"). Fig. 3/2/1-1 gives an overview over the characteristics of the physical layer types.

[1] Fan-in model allowing non-standardized EED’s is under consideration.

Characteristics	Description TP64	Description TP256
Medium	shielded twisted pair	shielded twisted pair[2]
Topology	linear, star, tree or mixed	Linear, star, tree or mixed
Baud rate	9600 bps	9600 bps
EED supplying	normal: bus powered devices optional: remote powered devices	normal: bus powered devices optional: remote powered devices
EED power consumption	3-12 mA	3-12 mA
Power Supply Unit (PSU)	DC 30 V	DC 30 V
Number of PSU's per physical segment	max. 2	max. 2
Number of connectable EED's per physical segment	max. 64	max. 256
Number of addressable EED's per physical segment	max. 255[3]	max. 255
Total cable length per physical segment	max. 1000 m	max. 1000 m
distance between two devices	max. 700 m	max. 700 m
Total number of EED's in a network	over 65000 (with bridges)	over 65000
Protection against shock	SELV (Safety Extra Low Voltage)	SELV (Safety Extra Low Voltage)
Physical signal	balanced baseband signal encoding	balanced baseband signal encoding

Fig. 3/2/1-1: System Parameters of Physical Layer Type TP64 and TP256

Fig. 3/2/1-2 shows the logical structure of the EIB physical layer type TP entity. Every EIB End Device includes one; every router and bridge is equipped with two such physical layer type TP entities.

The physical layer type TP entity consists of four blocks:

- Cable (Medium)
- Connector: Connects an EED or a bridge to the transmission medium.
- Medium Attachment Unit (MAU) : Converts information signals to analog signals and vice versa. Typically extracts DC power from the medium.
- Logical Unit: Converts the serial bit stream to octets and octets to the serial bit stream, which is a serial stream of characters.

[2] The shield is not mandatory, shielded cables with earth connection can improve noise immunity.

[3] In TP64 a physical segment can be extended with up to 3 extra physical segments, each connected to it via a bridge. Every physical segment can contain 63 EED's.

Fig. 3/2/1-3 shows the relationship between the bits of an octet and the UART character data bits.

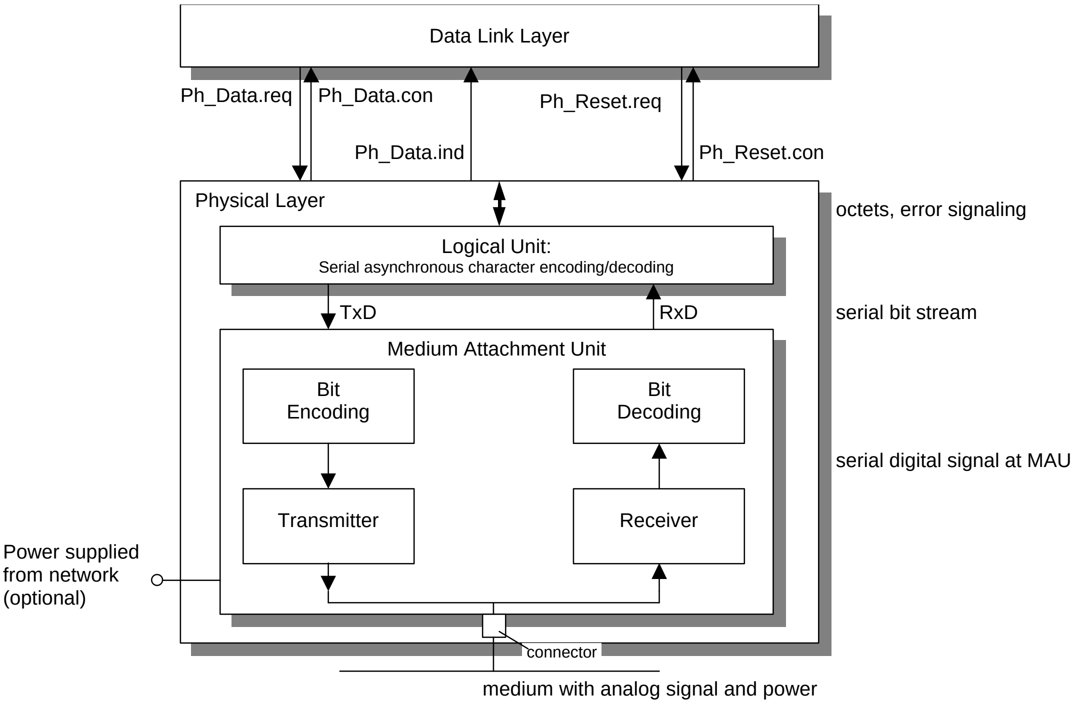

Fig. 3/2/1-2: Logical Structure of Physical Layer Type TP

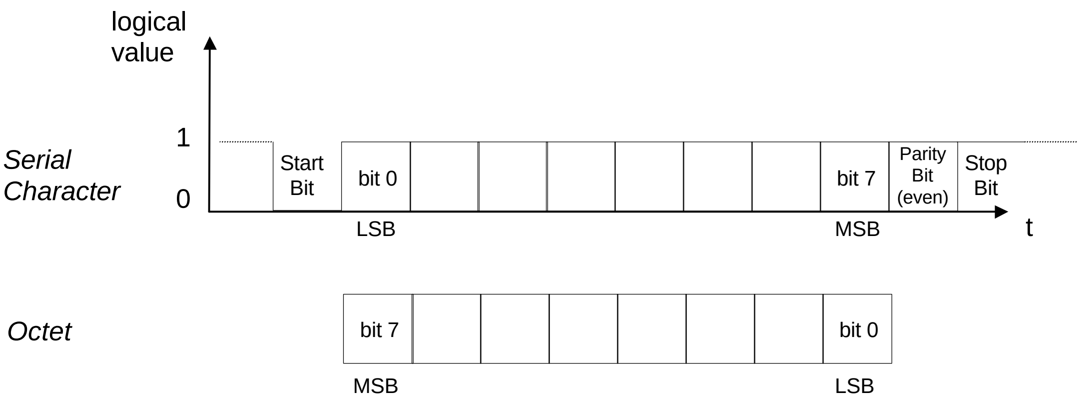

Fig. 3/2/1-3: Octet mapped to a Serial Character

1.1 General Requirements for Analog Bus Signals

In the underneath description, U_{REF} is an internal reference voltage for the DC part of the bus voltage, used by the transmitter/receiver for evaluating the sent/received signal levels and sampled before the start bit of a byte. These U_{REF} may vary with the values as indicated in clause 1.1.4.

The underneath specifications classify a 0 and 1 signal on the bus : the requirements for signal generation and extraction for the transmitter respectively receiver as defined in 1.2.1.5 and 1.2.1.6.

1.1.1 Definition of Logical ´1´

A logical ‘1’ can be regarded as the idle state of the bus, that means that the transmitter of a MAU is disabled during sending a ‘1’. The analogue signal at the bus consists normally only of the DC-Part. There is no difference between sending a ‘1’ and sending nothing. A decline of voltage during a ‘1’ can occur, if a ‘0 bit’ was preceding. The graph shall be within the gray shaded areas.

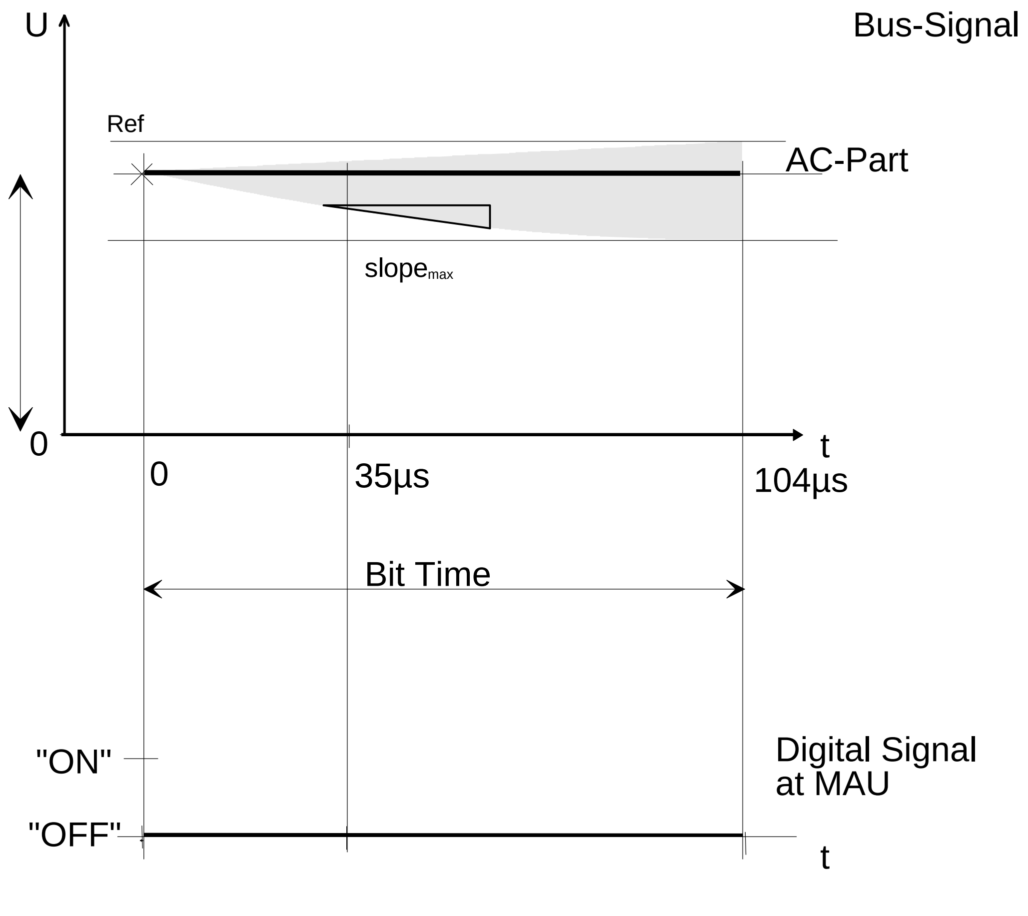

Fig. 3/2/1-4: “1”-Bit Frame (U_P udnd U_N entfallen bzw. AC-Part)

Parameter	Value
bit-time	104µs
voltage (DC-Part)	21-32 V_{DC}
slopes (AC-Part)	max. 400 mV/ms

Fig. 3/2/1-5: Analog and Digital Signal of a Logical ´1´

1.1.2 Definition of Logical ´0´ (Single)

A logical ´0´ is a defined voltage drop (U_a) of the analog bus signal with a duration of t_{active} (see Fig. 3/2/1-6). During the following equalization time the voltage can be higher than the DC-Part to enable recharging of energy consumed during the active part. The graph shall be within the gray shaded areas.

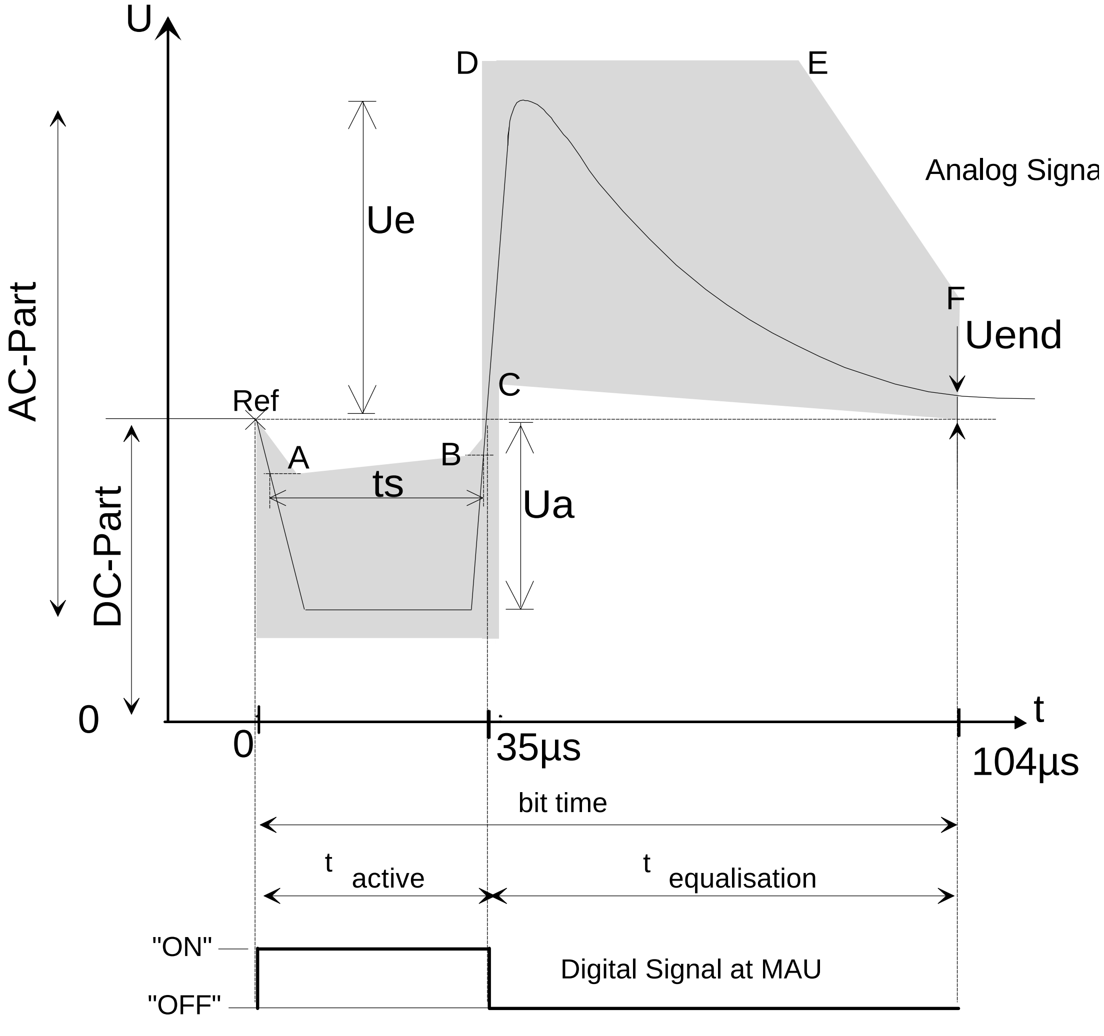

Fig. 3/2/1-6: "0"-Bit Frame

Parameter / Point	min	max
bit-time	104µs (typ)	
t_{active}	35µs (typ)	
t_s (time between Ua > A and Ua > B)	25µs	70µs (see also 1.1.3)
time (Point D - E)	50µs	
voltage (DC-Part)	21V	32V
voltage Ua (Point A) concerning Ref	-0,7V	-10,5V
voltage Ua (Point B) concerning Ref	-0,1V	-10,5V
Voltage Ue (Point C - D) concerning Ref	0V	+13V
voltage Uend (Point F) concerning Ref	-0,35V	+1,8V

Fig. 3/2/1-7: Analog and Digital Signal of Logical ´0´

1.1.3 Definition of Logical ´0´ (Overlapping)

Overlapping means, that a logical ´0´ is transmitted at the same time from several EED's (e.g. common ACK). Due to the propagation delay of the bus cable (PhL-Medium) a time shift of logical zeros can occur, if sending devices are far away located. The MAU and the MDS shall be able to handle these signals. Fig. 3/2/1-8 shows an example of two mixed logical ´0´ that have a delay (td) of about 10µs. Assuming that the point of measuring is at device A, the signal of device B appears after 10µs with a lower signal amplitude than device A, because it is damped along the bus cable.

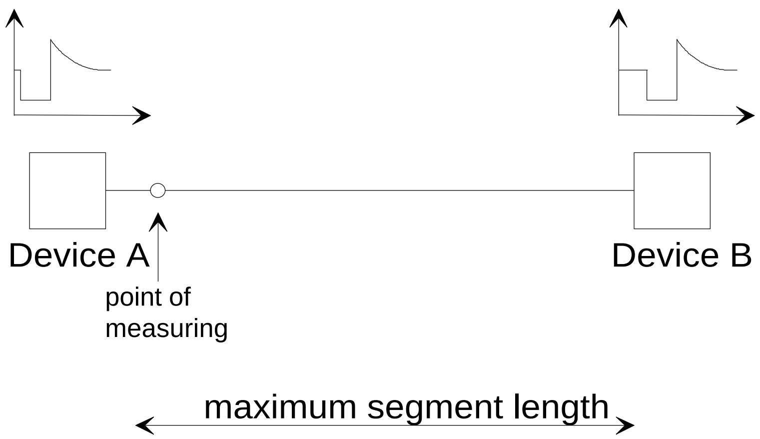

Fig. 3/2/1-8: Delayed Logical '0'

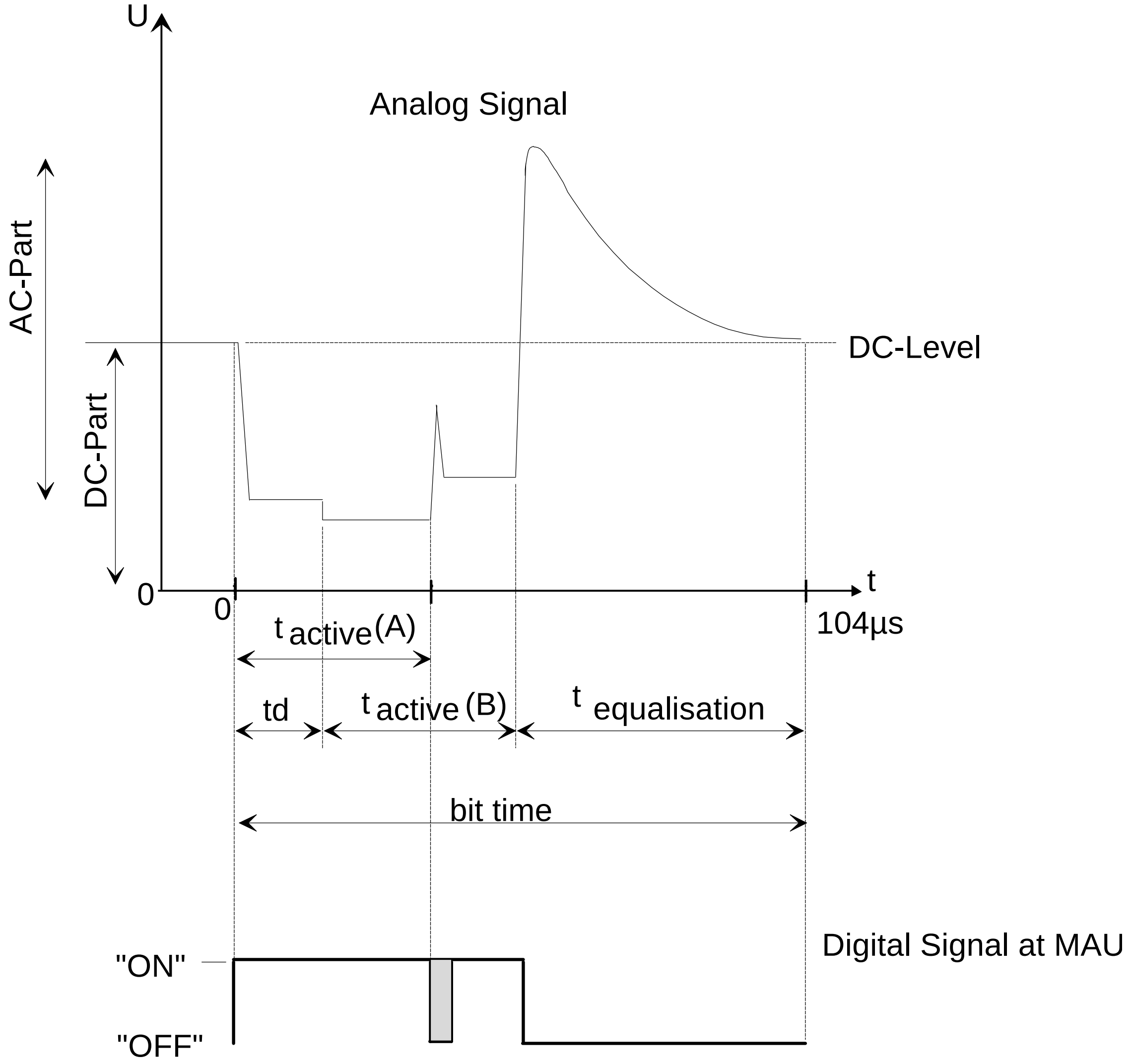

Fig. 3/2/1-9: Overlapping of Logical ´0´ (Example)

The receiver of MAU converts this mixed analog signal to a digital signal. This digital signal differs from that of a normal ‘0’, because the width of the receiver’s output pulse is the sum of t_{active} + td. However, it is possible, that the receiver’s output delivers a gap at the end of t_{active}. (See gray shaded area in Fig. 3/2/1-9.) This behavior requires dedicated decoding software that is able to decode such effects.

1.1.4 Analog Requirements within a Byte

Chapters 1.1.1 and 1.1.2 describe the voltage shape and timing within a logical bit. Within a byte which consists of a series of bits, additional requirements have to be met. The values Ua* and Ue* are referred to Uref at the beginning of the active part of the first bit of the transmitted byte.

Parameter	Value
Ua*	max. –10,5V
Ue*	max. 11,5V
Uref (any bit)	max. -1V / +3V

Fig. 3/2/1-10: Limits within a Byte

1.1.5 Simultaneous Sending / Collision Behavior

Although devices are investigating the busline before they begin sending it can occur that two or more EED’s are sending simultaneously. Simultaneous sending of a byte is intended in case of transmitting ACK (NACK, BUSY) messages.

Sending of logical ‘0’ and logical ‘1’ at the same time result in a logical ‘0’.

Simultaneous sending of logical ‘0’ from several EED’s results in a signal which is nearly the same as that of a single transmitting device, because signal is coded in baseband.

This common signal has also to comply with Fig. 3/2/1-7.

If a sending device detects that an own logical ‘1’ was overwritten by another logical ‘0’, transmission has to be disabled after this bit, however the receivers of both devices are still in progress.

This behavior of physical layer allows a CSMA/CA medium access in layer-2 (see paragraph 2 "Data Link Layer Type Twisted Pair (DL TP)").

1.2 Medium Attachment Unit (MAU)

The MAU splits the analog signal of the medium into the DC part and the serial bit stream. Vice versa the serial bit stream is converted to the analog bus signal.

The DC-Part is used internally to supply the device with power by using a DC/DC converter or voltage regulator. A wrongly connected MAU shall neither damage the device nor influence the bus communication.

1.2.1 General Requirements for EED's within a Physical Segment

Within a physical segment the following principal requirements have to be met:

- In an installed system the DC voltage at every EED shall be at least 21 V [4] [5]
- The propagation delay of the serial bit stream at the MAU shall be short enough to allow bit-wise CSMA/CA arbitration during a bit time. The total delay (MAU - Cable - MAU) shall not exceed 12 µs. Refer also to see paragraph 2 "Data Link Layer Type Twisted Pair (DL TP)"clause 2.3 clause "Medium Access Control".
- The PSU(s) connected to a physical segment shall provide the necessary effective current required by the devices connected to the physical segment.
- SELV requirements have to be met.

1.2.1.1 Switch On Behavior

Bus devices (EED's) have to meet certain criteria for powering up. Powering up means, that a single bus device is either connected to a 'running' bus segment or that a complete bus segment is switched to a Power Supply Unit (PSU). The difference is that the rising of busvoltage is different. "Switch On" procedure can be divided into three parts:

- *Idle*: Below 18 V the Power-Converter draws only a leakage current.
- *Start-up*: The internal capacitors are being charged with a current limitation.
- *Operation*: The capacitors are charged, voltages are constant.

Switch on behavior requires, that

- bus devices run up properly at any permitted topology if the associated segment is powered on by the PSU (slow ramp).
- a single bus device runs up properly if connected to an operating bus segment. Other bus devices at this segment shall not suffer a 'reset' due to this connection (steep ramp).

[4] Note: EED's have to work with a DC voltage down to 20V!. 21V are mandatory for the installer to get a reserve.

[5] Note: A voltage drop below 18 VDC in bus-powered EIB devices with critical parameters/values in a volatile memory /RAM) may generate a call to a save routine which stores data in a non-volatile memory.

- a possible signal disturbance, caused by the connection of a single bus device to an operating segment, takes not more than 20 ms to avoid telegram losses.

1.2.1.2 Switch Off Behavior

The Switch-off behaviour occurs when the input to the power converter of the device breaks down. This input can either be the DC Part of the bus voltage or a remote power source (see 1.2.2).

The switching off behaviour can also be divided into three parts.

- *Operation:* The capacitors are charged, voltages are constant.
- *hold-up:* Capacitors are discharged.
- *Idle:* The power converter draws only a leakage current.

When switching from operation to hold-up, the Physical Layer may optionally generate signal Usave.

- to allow devices to backup data before power breaks down
- to disable further transmission of telegrams by the bus device

For bus powered devices, this Usave signal shall be generated when the bus voltage drops below 20 V max., thereby taking into account a hysteresis of at least 1 V.

The Physical Layer shall generate a Reset Signal when the correct functioning of the power converter can no longer be ensured, i.e. before the end of the hold-up time. This may be manufacturer specific. For a bus powered device the Ureset signal may not be generated for input voltages higher than for Usave.

1.2.1.3 DC Behavior

Bus devices may not draw more than the specified DC current from the bus to comply with the maximum number of connectable EED's per segment which are defined in the system parameters (Fig. 3/2/1-1). This current shall not be exceeded at worst case (20 V busvoltage and max. application consumption). The manufacturer has to specify the DC current in the product database.

Load changes within an EED shall not disturb the signal voltage from the bus in any way. Fast current changes inside an EED shall be transformed (smoothened) to slow slopes at bus side.

Parameter	TP64/TP256
Bus current (at 20V - 32V)	max. 12 mA
slope of input current	max. 0,5 mA/ms
slope of input current for manually operated devices (e.g. push buttons)	max. 2,5 mA/ms

Fig. 3/2/1-11: Unit Currents for Standard EED's

1.2.1.4 Impedance Behavior

The impedance of an EIB device is not only a property of the receiver. It is moreover valid for the complete device. Impedance behavior means, which current is drawn from the bus by an EED when the busvoltage has the shape of a square pulse (35/104µs). The impedance value within a pulse (T=104 µs) is not constant. The value during active part (t < 35 µs) is different to this of equalization part. A special test method is provided to check the input impedance of EED’s (see Part 8/2 "Medium Dependent Layers Tests"). Impedance matching is important to ensure that both signal damping is not too high and following bits are not disturbed by equalization event of preceding bits.

1.2.1.5 Transmission Behavior

If no frame is transmitted, the voltage between Bus (+) and Bus (-) is about 21 to 32 V DC, caused by the Power Supply Unit (PSU) and the voltage drop along the bus cable and the consumption of the devices. This state of the medium over a bit time of 104 µs corresponds to a logical ´1´. The logical ´1´ also indicates the idle state when no frame is being transmitted. The related output signal to the PhL MDS of the MAU is „OFF“ during the whole bit time.

In order to transmit a logical ´0´, the MAU shall draw an adapted current (I_{send}) to cause a defined voltage drop U_a of the analog signal with a duration of t_{active} (see also Fig. 3/2/1-7).

During the following equalization time the energy consumed during the active time may be partly charged back to the bus cable and the connected devices. Thus bus-powered devices do not suffer a relevant power drop during transmission of a logical ´0´. The AC part of the analog signal is mainly generated by the transmitter of the MAU and the choke module(s).

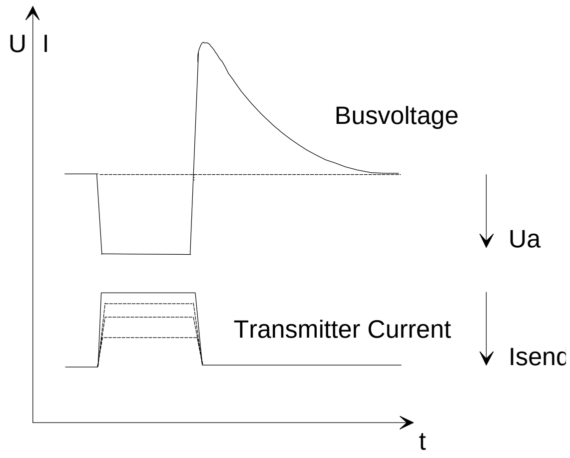

Fig. 3/2/1-12: Method of Transmitting

The value of send current of one EED depends on:

- number of connected bus-devices (EED’s)
- number of bus-devices that are sending simultaneously (e.g. in case of ACK)
- busvoltage
- segment cable length

Parameter	Value min.	Value max.
I_{send}	~ 0 mA[6]	400 mA[7]
U_A[8]	3 V	9 V

Fig. 3/2/1-13: Dynamic Requirements of a TP 64 Transmitter

Parameter	Value min.	Value max.
I_{send}	~0 mA	400 mA
U_A	3V	10 V

Fig. 3/2/1-14: Dynamic Requirements of a TP 256 Transmitter

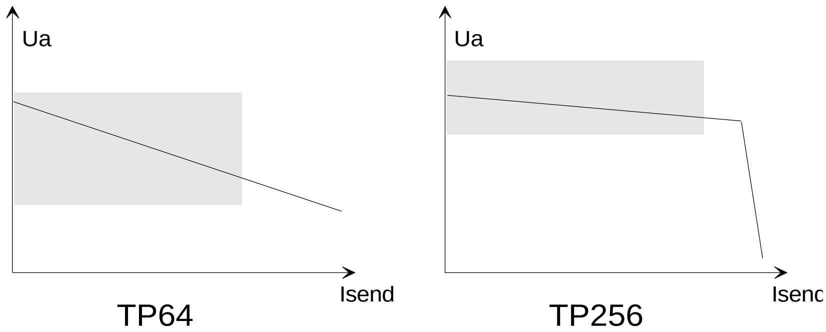

Fig. 3/2/1-15: Example of Transmitter Characteristics

[6] Valid for one EED if maximum number of EED's are sending simultaneously.
[7] Valid if only one EED is sending and the segment is equipped with maximum number of EED's.
[8] Measured at the EED

Fig. 3/2/1-16 shows an example of a principle diagram of a TP64 transmitter:

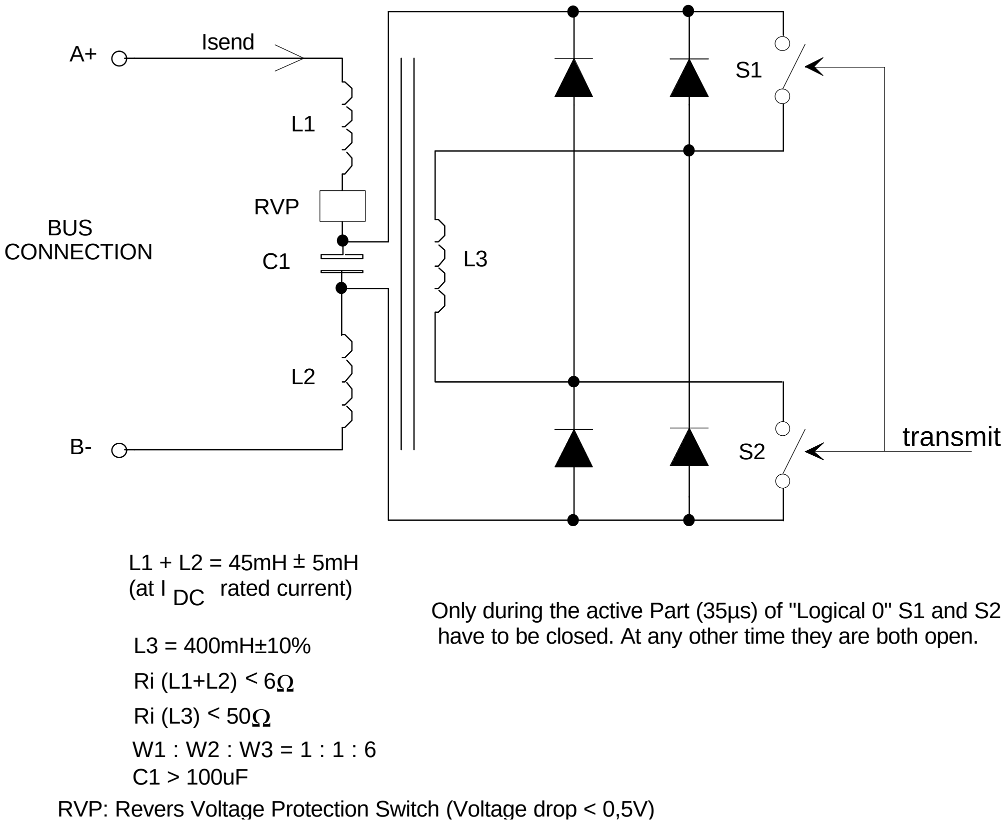

Fig. 3/2/1-16: Example of a Diagram of a TP64 Transmitter

Fig. 3/2/1-17 shows an example of a principal diagram of a TP256 transmitter:

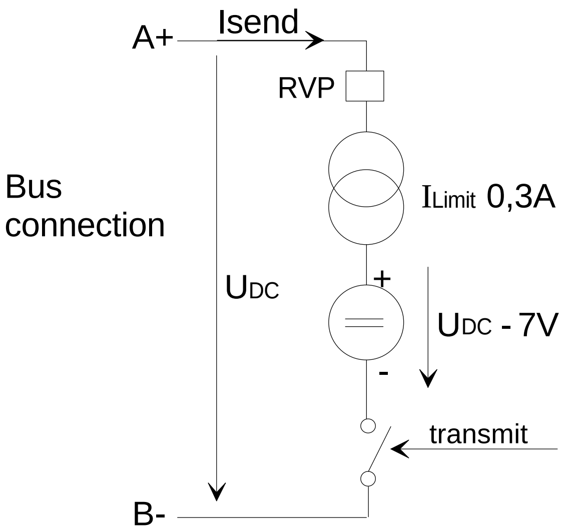

Fig. 3/2/1-17: Example of a Diagram of a TP256 Transmitter (I_{limit} 0,4A)

1.2.1.6 Receiving Behavior

The MAU has to convert an analog signal to a digital signal by using a receiver function (see Fig. 3/2/1-2). The required threshold voltages for the receiver are shown in Fig. 3/2/1-18. The relation of ON/OFF and the bus voltage are explained in Fig. 3/2/1-7. (See also test-specification in Part 8/2 "Medium Dependent Layers Tests".)

State at MAU	Threshold Voltage TP64 (relative to DC part)	Threshold Voltage TP256 (relative to DC part)
ON	0.5 V (typ)	0.6 V (typ)
OFF	0.2 V (typ)	0.3 V (typ)

Fig. 3/2/1-18: Requirements for the Receiver

1.2.1.7 Signal Coding

The MDS of MAU has to convert framed data bits into an asynchronous timed serial signal. This signal is used to drive the transmitter of MAU. The underneath figure shows an example for a digital signal and the resulting serial bit stream.

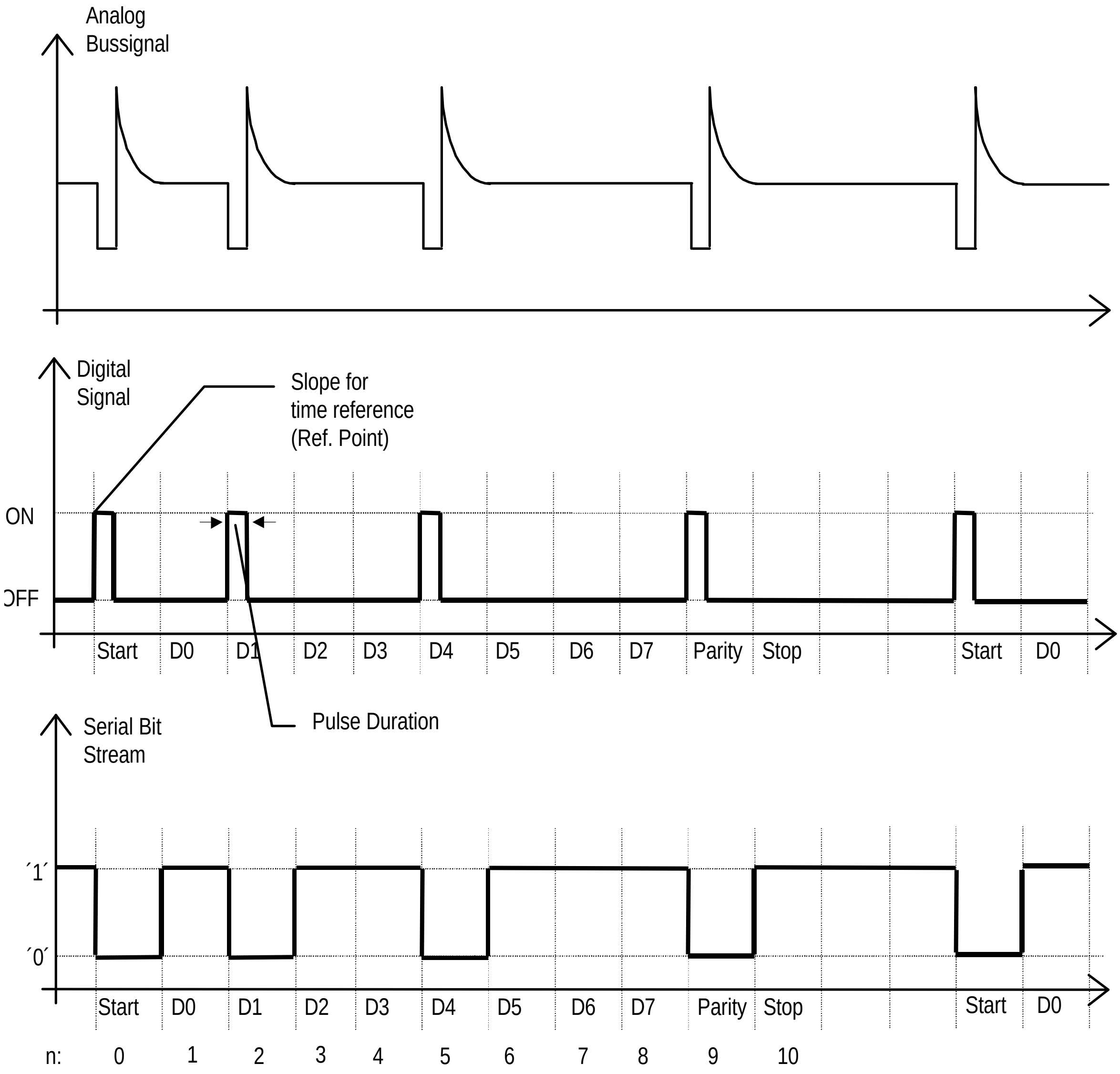

Fig. 3/2/1-19: Relation between Framed Data and Asynchronous Signal

Parameter	min.	typ.	max.
Bit Time		104µs	
Pulse duration	34µs	35µs	36µs
time from startbit to following bits (within a byte)	(n * 104) - 2µs	n * 104µs	(n*104) + 2µs
time from start-bit to startbit of consecutive bytes	(13* 104)-2µs	13* 104µs	(13* 104) + 30µs

Fig. 3/2/1-20: Requirements for Bit Coding

Additional timing information concerning structure of telegrams is given in paragraph 1.4 "Services of the Physical Layer Type TP" ‘ and see paragraph 2 "Data Link Layer Type Twisted Pair (DL TP)".

1.2.1.8 Signal Decoding

The output signal of the receiver, regarded as a digital signal, shall be decoded to the serial bit stream by the bit decoding unit of the MAU (see also Fig. 3/2/1-2). The following Fig. 3/2/1-21 shows an example for a digital signal and the resulting serial bit stream.

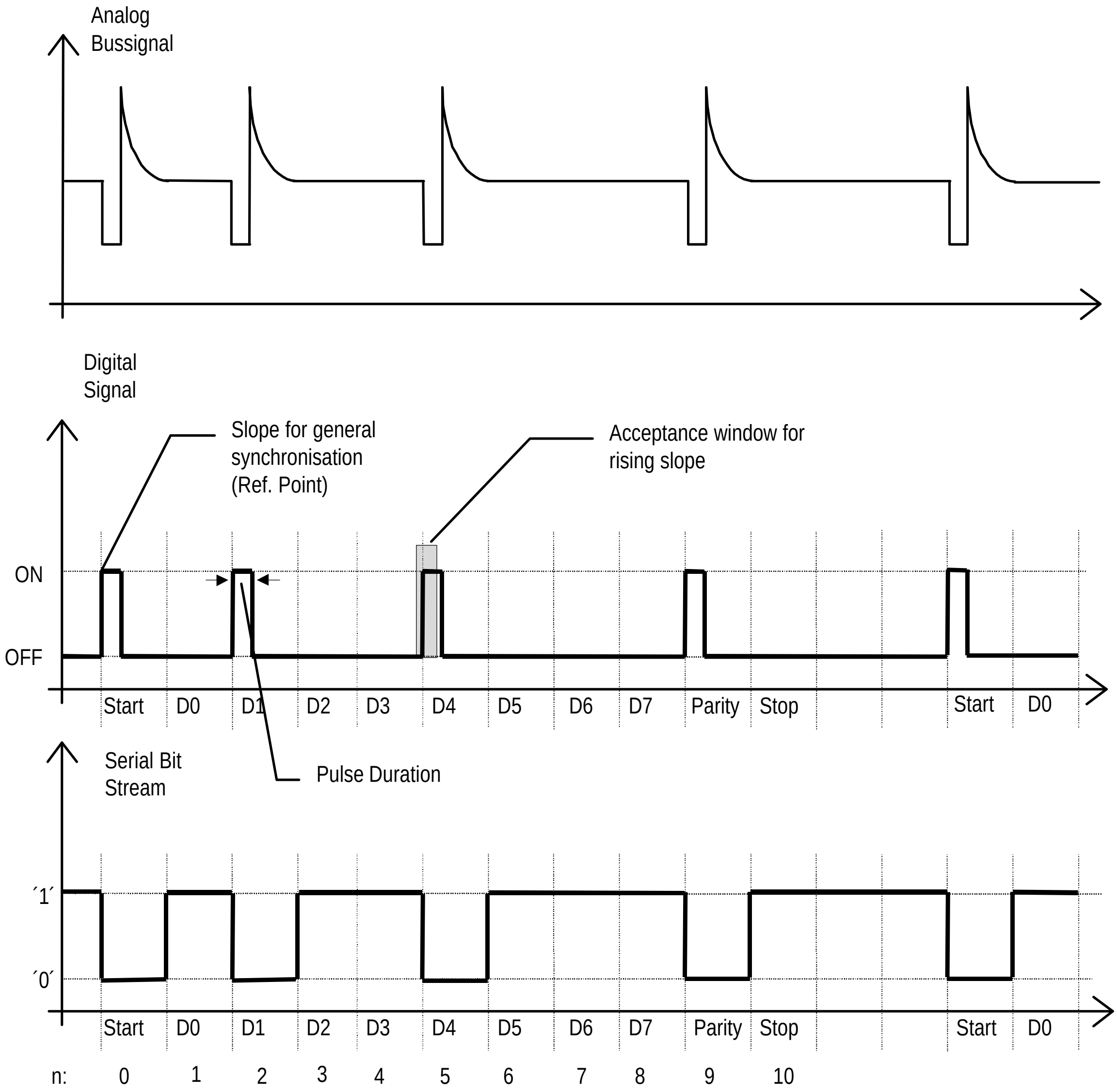

Fig. 3/2/1-21: Relation between Digital Signal and Serial Bit Stream

The bit-decoding unit of the MAU uses an acceptance time window. The beginning of the acceptance time window is defined in relation to the start bit. In addition minimum and maximum pulse duration is required. The corresponding values are listed in the following table (Fig. 3/2/1-22):

Parameter	minimum	typical	maximum
Bit Time		104 µs	
Pulse Duration	25 µs	35 µs	70 µs [9]
Acceptance window for the rising slope of a bit n, referred to rising edge of start bit (=Ref. point)	(n * 104) - 7 µs	n * 104 µs	(n * 104) + 33 µs
Time distance from start bit to start bit within a frame	(13 * 104) - 30 µs	13 * 104 µs	(13 * 104) + 30 µs

Fig. 3/2/1-22: Requirements for the Bit Decoding Unit

The physical layer guarantees that the transmission of a logical ´0´ is dominant versus the simultaneous transmission of a logical ´1´. It is also guaranteed that during the simultaneous transmission of bits of equal value from a number of devices, the resulting physical signal corresponds to the same logical value of the bit being sent. This behavior of the physical layer allows a CSMA/CA medium access in layer-2 (See paragraph 2 "Data Link Layer Type Twisted Pair (DL TP)"clause 2.3 clause "Medium Access Control"

1.2.2 Remote Powered Devices

1.2.2.1 General

Remote powered bus devices (RPD) do not extract their energy for the application circuit and the bus controller from the bus but from another independent source of energy, e.g. mains. They only draw a minimal DC current from the bus line (segment). The AC load is similar to a standard device. Due to the reduced DC power consumption of RPD, a bus line equipped with such devices requires less power from the installed Power Supply Unit(s).

The connection of bus-controller and application to the same electrical potential reduces the effort of galvanic separation in dedicated devices.

Galvanic separation can be implemented by using e.g. optical couplers or transformer. Only the transceiver is supplied from the bus line.

Fig. 3/2/1-23 shows an example of a remote powered device. Thus using remote powering it is possible to design a compact device for this dedicated application.

[9] see also Fig. 3/2/1-10

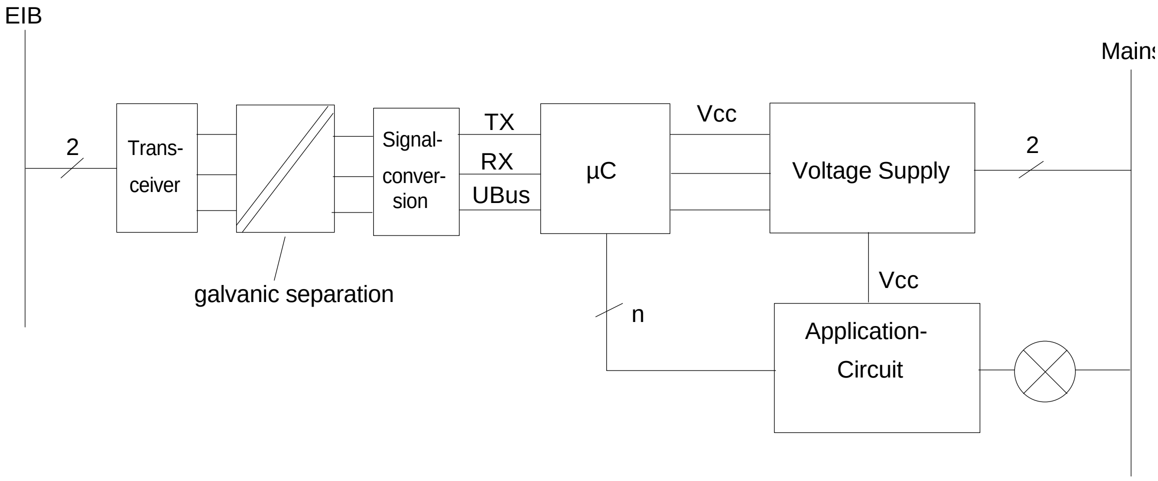

Fig. 3/2/1-23: Example of an EIB Light Dimmer

1.2.2.2 Reset and Save Behavior of RPD

RPD's have access to two independent power sources, bus voltage and remote voltage.

The device supplying voltage is regarded as master voltage. That means, that ramp up or breaking down of this source causes reset, save and init. Save and init are the routines that can be defined in the user program. They are executed if the device detects either voltage ramps up or breaks down. The missing of master voltage shall not disturb the operating bus segment in any way.

Bus voltage is regarded as slave voltage. The missing of bus voltage (U < 20 V DC) shall disable transmitting of telegrams from RPD.

The behavior of the device if either master or slave voltage is missing, shall be described in the manufacturers data sheet.

The manufacturer has to define how to reset a RPD. The device can also be forced to a reset from bus side, through sending a special reset service message.

1.3 Topology

1.3.1 Physical Segment[10]

EIB end devices are connected to a physical segment. The topology of a physical segment can be a linear, star or tree or mixed topology (see Fig. 3/2/1-24). To make the figures easier to read, they always depict one bus topology as a representative for a physical segment.

Up to 64 (TP64) or 256 (TP256) devices can be connected to a physical segment if the recommended bus cable is used. This corresponds to the logical address space of a bus line. The maximum distance between two devices in a physical segment is 700 m. The maximum cable length in a tree or star topology may be longer than the maximum distance between two devices. Therefore the maximum cable length of a physical segment is 1000 m for the recommended cables.

Loops within a physical segment are allowed but not recommended.

No terminating resistors are required.

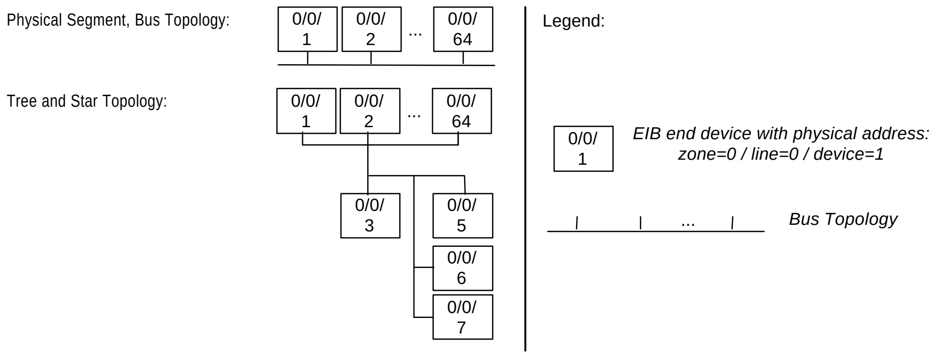

Fig. 3/2/1-24: Physical Segments

1.3.2 Bridge

Bridges are used to combine physical segments to a line in order to achieve longer distances and to allow up to 255 devices (Fig. 3/2/1-25) on a line with TP64 EED's. The bridge also guarantees a galvanic separation of the physical segments connected to improve noise immunity. Bridges can be used to connect up to four physical segments and achieve a total length of 4000 m. The maximum distance between two devices in a line is therefore 700 m x 4 = 2800 m for the recommended cables. Bridges do not have a physical address, but they acknowledge the frames they receive on layer-2 and transmit the received frame on the other side of the bridge.

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[10] The calculations in the subsequent text are based on a maximum of 64 devices in a physical segment, i.e. 3 x 64 = 192 devices per line. Of course in respect to the available logical address space 256 devices per line are used for computations.
Instead, the figures show an example system, in which only two physical segments (i.e. one bridge) are used per line. Therefore in the figures there are in the maximum 128 devices shown.

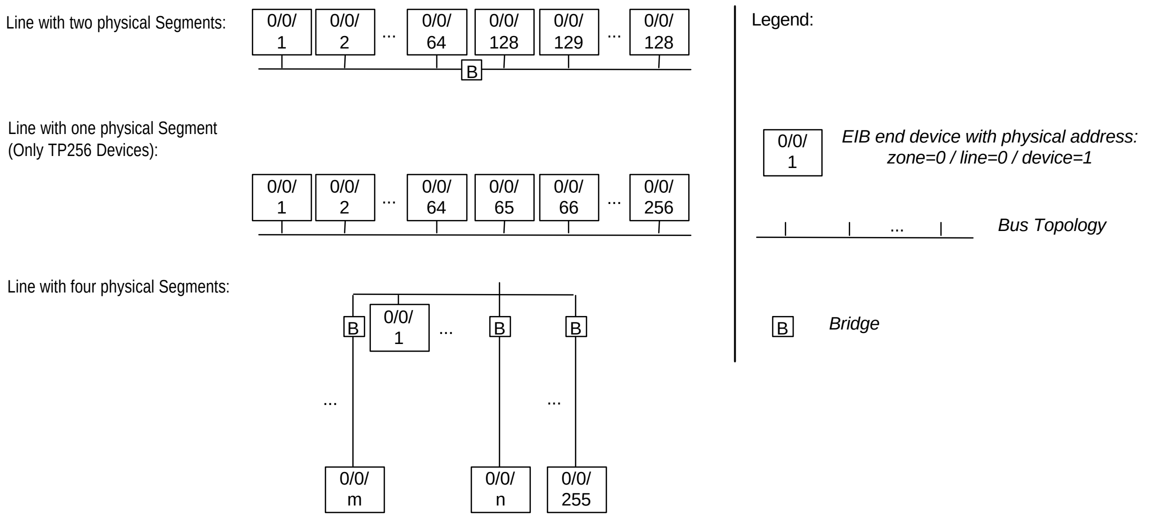

Fig. 3/2/1-25: Physical Segments Combined to a Line

To simplify the following figures, a line is always shown as two physical segments having 128 devices.

1.3.3 Router, Sub-line, Main Line and Zone

A router has a physical address and will acknowledge frames on layer-2 and transmit the received frame on the other side of the router, if the EIB end device (EED) associated with the destination address of the frame is located on the other side. For larger networks, up to 16 lines can be combined to a zone using 15 routers (Fig. 3/2/1-27). Not more than two routers shall be in the path between any of two EIB end devices of a zone. The inner line of a zone is also called main line, the outer lines of a zone are also called sub-lines or lines.

The router also guarantees the galvanic separation of the lines connected.

Routers that combine lines to a zone are called line couplers (LC).

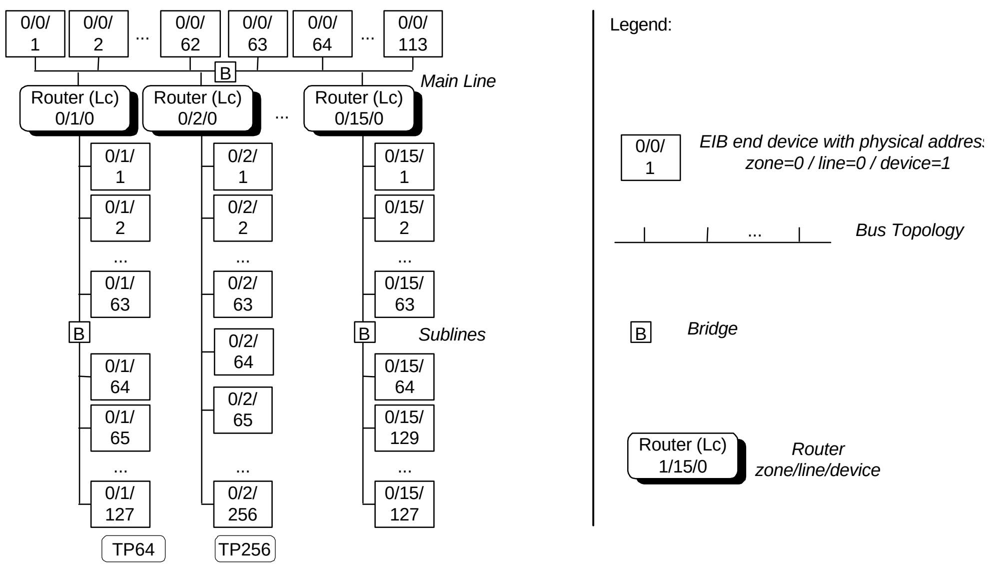

Fig. 3/2/1-26: Lines combined to a Zone

Using the recommended cables and bridges a zone may therefore have 256 x 16 = 4096 devices and an extension of 4000 m x 16 = 64 km.

The maximum distance between two EIB end devices in a zone is then 700 m x 6 = **!Syntax Error, .** km.[11]

Routers can also be used to connect multiple zones to a maximum size EIB network (Fig. 3/2/1-27). These routers are called backbone couplers (BbC). Up to 16 zones can be connected using 15 backbone couplers. Not more than two backbone couplers shall be in the path between any of two zones. The main line of the inner zone is called backbone line.

A maximum size EIB network may therefore have up to 4096 x 16 = 65536 devices and a total network extension of 64 km x 16 = 1024 km.

Not more than 6 coupling devices (i.e. bridges or routers) shall be between any of two EIB end devices. The maximum distance between two EIB end devices in a maximum size EIB network using the recommended cables is then 700 m x 7 = **!Syntax Error, .** km.

1.3.4 Gateways to Other Networks

Gateways connect EIB systems to networks with communication layers different from the corresponding EIB layers. Gateways may be included at any line. Gateway connections shall additionally be in conformance with the relevant national regulations.

Note: Zones may be linked together not only by using the EIB backbone line but also by using higher level bus systems like ISDN or PROFIBUS, then requiring dedicated gateways.

1.3.5 Network Topology Configuration Rules Summary

Recommendation: A new EIB system normally should not contain a bridge. The bridges should be used for later extensions only.

A maximum of 6 line controllers is allowed in one transmission path; a line controller is either a bridge, a line coupler or a backbone coupler.

The connection of non-SELV lines to an EIB system is not allowed.

There shall be no terminating resistors for matching purposes at the ends of the wires.

[11] ... true on the supposition that in the maximum there is only one bridge between any two EED’s.

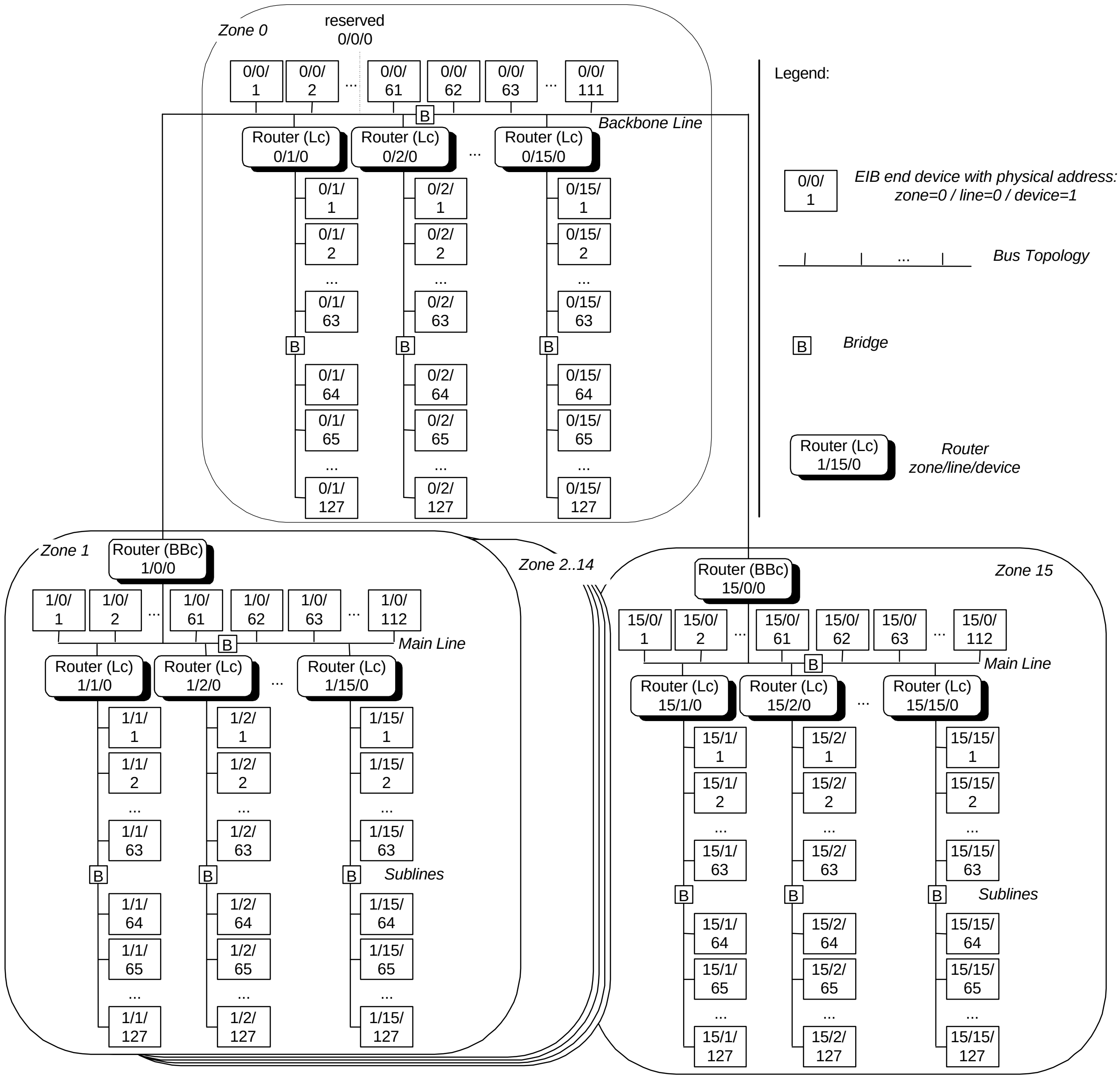

Fig. 3/2/1-27: Network Topology

1.4 Services of the Physical Layer Type TP

At the interface to the physical layer user the physical layer type TP offers the Ph_Data service and the Ph_Reset service.

1.4.1 Ph_Data Service

The Ph_Data service consists of three primitives Ph_Data.req, Ph_Data.ind and Ph_Data.con.

Ph_Data.req(p_class, p_data)

p_class: start_of_frame;	transmit character after 53 bit times **with** line_busy detection at the start bit
start_of_repeated_frame;	transmit character after 50 bit times **with** line_busy detection at the start bit
inner_frame_char;	transmit character after two bit times **with** line_busy detection at the start bit
ack_char;	transmit character 15 bit times after the preceding character received **without** line_busy detection at the start bit
poll_data_char;	transmit character 5 bit times after the preceding character received **without** line_busy detection at the start bit
fill_char;	transmit character 6 bit times after previous character received **with** line_busy detection at the start bit
p_data: octet;	the octet to be converted to a UART character and to be transmitted.

The Ph_Data.req primitive is applied by the physical layer user to pass user data consisting of an octet via the p_data parameter to the physical layer type TP. The p_class parameter describes the transmission task to be executed by the physical layer type TP entity.

See 1.5 for a more detailed description of line_busy detection at the start bit.

Ph_Data.con(p_status)

p_status: OK;	character transmission succeeded
line_busy;	no transmission, another device is transmitting
collision_detected;	a collision was detected (logical ‘1’ transmitted, but logical ´0´ received
transceiver_fault;	transceiver fault detected

The Ph_Data.con primitive passes status information via the parameter p_status back to the physical layer user. The value of p_status indicates whether the transmission of the contents of the p_data parameter previously passed to the physical layer type TP entity via the Ph_Data.req primitive succeeded.

P_status shall be ‘collision_detected’ if a logical ‘1’ was transmitted as one of the UART character bits, but at the same time a logical ‘0’ was read at the line by the physical layer type TP entity. P_status shall be ‘transceiver_fault’ if a logical ‘0’ was transmitted as one of the UART character bits, but at the same time a logical ‘1’ was read at the line.

See 1.5 for a more detailed description of the conditions for p_status values ‘line_busy’, ‘collision_detected’ and ‘transceiver_fault’.

Ph_Data.ind(p_class, p_data)

p_class: start_of_frame;	character received at least 50 bit times after the preceding one
inner_frame_char;	character received at 2,0 to 2,5 bit times after the preceding one
ack_char;	character received 15 bit times after the preceding one
poll_data_char;	character received at five or six bit times after the preceding one
parity_error;	wrong parity bit detected in the character received
framing_error;	wrong stop bit detected in the character received
bit_error;	wrong data bit detected in the character. Data bit did not meet the bit decoding rules,
p_data: octet;	the data octet extracted from the received character

The Ph_Data.ind primitive passes timing information via the parameter p_class and user data via the parameter p_data from the physical layer type TP entity to the physical layer user. See 1.5 for more details.

1.4.2 Ph_Reset Service

The Ph_Reset service is applied by the user of layer-1 during start up, in order to synchronize to possibly existing network traffic.

Ph_Reset.req();	start synchronisation activity
Ph_Reset.con(p_status);	
p_status: OK;	a bus free time of 50 bit times was detected
transceiver_fault;	undefined physical signal detected.

The Ph_Reset.con primitive indicates either with value ‘OK’ of parameter p_status an idle time of 50 bit times or with ‘transceiver_fault’ a malfunctioning transceiver.

1.5 Behavior of the Physical Layer Type TP Entity

In addition to the rules listed in the description of each physical service (see 1.4) the following rules also apply for the physical layer type TP entity:

Line_busy detection means that immediately before the transmission of the start bit of a character, the physical layer type TP entity shall check if another physical layer type TP entity is already transmitting at the same physical segment.

According to clause 1.4.1 line_busy detection is on for the p_class values ‘start_of_frame’, ‘start_of_repeated_frame’, ‘inner_frame_char’ and ‘fill_char’ of the Ph_Data.req primitive. In these cases the Ph_Data.req primitive may result in no transmission and in a Ph_Data.con primitive with p_status = line_busy.

On the other hand the p_class values ‘ack_char’ and ‘poll_data_char’ will result in the transmission of the start bit and subsequent data bit transmission with collision detection on. In that case a Ph_Data.con primitive with p_status = line_busy cannot occur.

During transmission (i.e. during Ph_Data.req primitive execution) collision detection shall never be disabled. If a collision is detected, then the transmitter shall immediately stop its transmission. Collision detection shall be indicated by a Ph_Data.con primitive with p_status = ‘collision_detected’. The following Ph_Data.ind primitive (p_class either of value ‘start_of_frame’ or ‘inner_frame_char’) shall pass the p_data value with the complete octet received to the physical layer user.

2. Data Link Layer Type Twisted Pair (DL TP)

The data link layer described in this clause is called data link layer type twisted pair (TP). Its medium access corresponds to a CSMA/CA mechanism, Carrier Sense Multiple Access with Collision Avoidance.

2.1 Physical Address/Group Address

Each device, i.e. a router or an EIB end device shall have a unique physical address in an EIB network. The physical address is a two-octet value that consists of an 8-bit device number, a 4-bit line number and a 4-bit area number.

Physical Address															
Octet 0								Octet 1							
8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
area number				line number				device number							

Fig. 3/2/1-28: Physical Address

The device number shall be unique within a line. Routers shall always have the device number zero; i.e. EIB end devices may have the device numbers 1-255. See also paragraph 1.3.3 "Router, Sub-line, Main Line and Zone" for details.

The line number shall be unique within an area (0-15). The devices in the main line of an area shall always have the line number zero.

The area number shall be unique within an EIB network (0-15). The devices in the inner area shall always have the area number zero.

Group Address															
Octet 0								Octet 1							
8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
	main group				sub group										

Fig. 3/2/1-29: Group Address

The group address is a two-octet value that doesn't need to be unique. An EIB end device may have more than one group address.

Each EIB end device belongs to group zero, i.e. request frames with destination group address zero are broadcasts.

2.2 Frame Formats

The data link layer has exactly the three frame formats shown in the subsequent figures. Other frame formats shall not be received. Each frame is being sent as a sequence of characters. The subsequent figures show octets instead of UART characters, i.e. the LPDU, to make it easier to read. The UART character that corresponds to octet 0 is sent first, the octet with the highest number is the last character being sent. The individual bits of an octet are sent in ascending order, i.e. the lowest significant bit (bit 1) is sent first. The different frame formats differed in the control field.

2.2.1 Control Field

The first character of each frame is the control field. The control field contains the information about the layer-2 service, its class and a flag containing the information whether the LPDU is a repeated one, see Fig. 3/2/1-30.

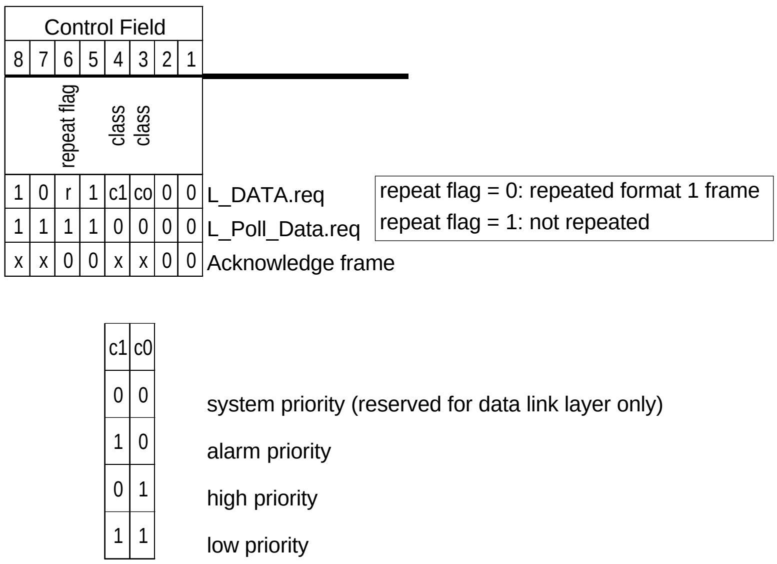

Fig. 3/2/1-30: Control Field

The control field indicates the type of the request frame, L_Data-, L_Poll_Data request frame or Acknowledgment frame. The two class-bits of the control field control the priority of the frame, if two devices start transmission simultaneously.

Repeated format 1 frames have the repeat_flag set to zero, non-repeated ones have it set to one.

<u>Note</u>: The control field encoding '01r0 c_1 c_0 00' shall not be used for future extensions of the data link layer twisted-pair protocol.

2.2.2 L_Data-Frame

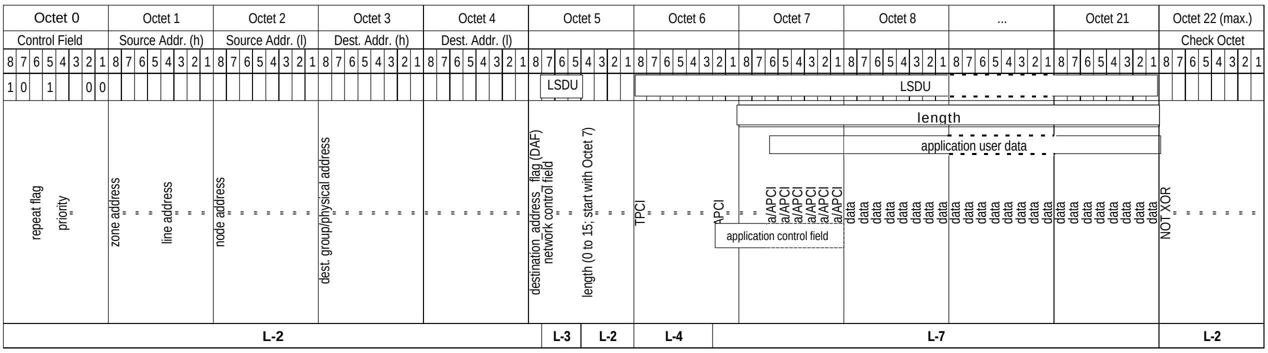

Fig. 3/2/1-31: Format 1, L_Data Request Frame Format

Most of the services used from an EIB end devices are coded as L_Data-Frame. The L_Data frame is the standard frame on the EIB.

2.2.2.1 Source Address

The octets one and two of a request frame are the high and lower octet of the source address. This is the physical address of the EIB end device that caused the transmission of the frame.

2.2.2.2 Destination Address and Destination Address Flag (DAF)

The destination address (octets three and four) defines the EIB end device(s) that shall receive the frame. For L_Data request frames, the destination address can be either a physical address (DAF=0) or a group address (DAF=1), depending on the destination address flag (DAF) of octet five.

2.2.2.3 Length

The L_Data request frame format has a variable length. The maximum length is 23 characters. Octet 5 indicates the number of characters (0-15) of the L_Data request frame starting with the seventh octet. That means that a L_Data request frame with length 0 ends after the sixth octet.

2.2.2.4 Check Octet

The last octet of a request frame is the check octet (Fig. 3/2/1-32) which makes an odd parity over the set of corresponding bits belonging to the preceding octets of the frame. This represents a logical NOT XOR function (F in Fig. 3/2/1-32) over the individual bits of the preceding octets of the frame.

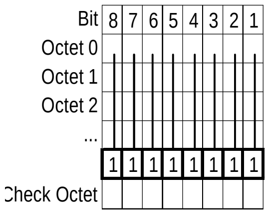

Fig. 3/2/1-32: Check Octet

2.2.3 L_Poll_Data-Frame

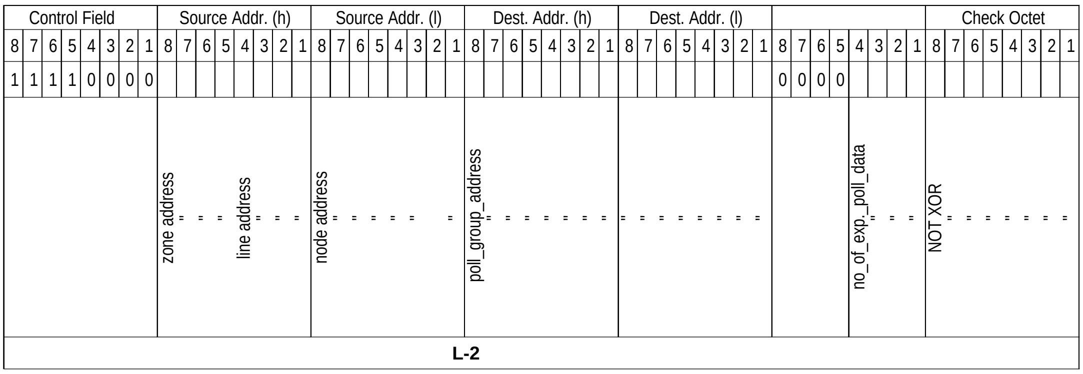

Fig. 3/2/1-33: Format 3, L_Poll_Data Request Frame Format

The Poll_Data request frame is shown in Fig. 3/2/1-33. The EIB end device that transmits the Poll_Data frame is called Poll_Data master.

The Poll_Data response frame is shown in Fig. 3/2/1-34, consisting of a variable number of Poll_Data or FILL (0xFE) characters. In Fig. 3/2/1-34 each gray box symbolizes a character. There is five bit times idle time before a Poll_Data character is transmitted and 6 bit times idle time before a FILL character is transmitted. A Poll_Data character transmitter is called Poll_Data slave. Each Poll_Data slave shall know his poll group and his response slot number.

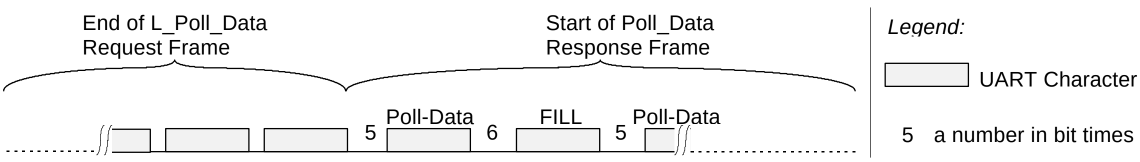

Fig. 3/2/1-34: Format 4, L_Poll_Data Response Frame Format

2.2.3.1 Source Address

The octets one and two of a request frame are the high and lower octet of the source address. This is the physical address of the EIB end device that caused the transmission of the frame.

2.2.3.2 Destination Address / Poll Group Address

The destination address (octets three and four) defines the EIB end device(s) that shall receive the frame. For L_Poll_Data request frames the destination address is always a poll group address. The poll group address shall be unique in the physical segment the Poll_Data request frame is transmitted. The poll group address addresses up to 15 Poll_Data slaves (slot 0-14) belonging to the same poll group.

2.2.3.3 Number of Expected Poll Data

The Number of Expected Poll Data is contained in the Poll_Data request frame. It is a number of {1…15} and tells how many Poll Data characters are expected in the subsequent Poll_Data response frame.

2.2.3.4 Check Octet

The last octet of the poll data request frame is the check octet (Fig. 3/2/1-32) which makes an odd parity over the set of corresponding bits belonging to the preceding octets of the frame. This represents a logical NOT XOR function (F in Fig. 3/2/1-32) over the individual bits of the preceding octets of the frame.

2.2.3.5 Poll Data Slaves and Poll Data Octet

The poll data octet represents the information that has to be transmitted by the Poll_Data slave in his response slot (0-14) in case his poll group is addressed in a Poll_Data request frame. The data link layer user may choose any value of {0..0xFF} \ {0xFE} for the poll data octet. 0xFE is reserved by the data link layer protocol.

2.2.4 Acknowledge-Frame

The short acknowledgment frame format consists of 15 bit times idle time followed by a single character which is used to acknowledge an L_Data.req frame (see also Fig. 3/2/1-36). The following figure shows the corresponding codes of the short acknowledgment.

Octet 0								
Short ACK								
8	7	6	5	4	3	2	1	
1	1	0	0	1	1	0	0	ACK
0	0	0	0	1	1	0	0	NAK
1	1	0	0	0	0	0	0	BUSY

Fig. 3/2/1-35: Format 2, Short Acknowledgment Frame Format

2.3 Medium Access Control

The EIB twisted pair's medium access control is CSMA/CA, Carrier Sense Multiple Access with Collision Avoidance. CSMA/CA means that collisions shall be resolved within a bit time. CSMA/CA relies on the bitwise collision avoidance mechanism described in Volume Three, Part One, Layer-1, clause "Ph Data Service".

Fig. 3/2/1-36 shows the character timings during the data link message cycle. Each gray box symbolizes a UART character.

Before a device may start the transmission of a request frame it has to wait for at least 50 bit times line idle since the last bit of the preceding data link message cycle. A data link message cycle always consists of a data link request frame and the subsequent data link acknowledgment or a subsequent data link response frame.

It may occur that devices start transmitting at the same time. Due to the CSMA/CA algorithm, which avoids frames being disturbed by a collision, a transmitting device has to check for each individual bit, if the bit value that has been sent equals to the bit value that has been received at the same time. If the physical layer indicates line busy or a collision, then the transmission of a frame with higher priority sent by another device is in progress. To avoid further collisions, transmission shall be stopped immediately within that bit time. All frame parts that have already been sent shall be interpreted as being part of the higher priority frame whose transmission is in progress.

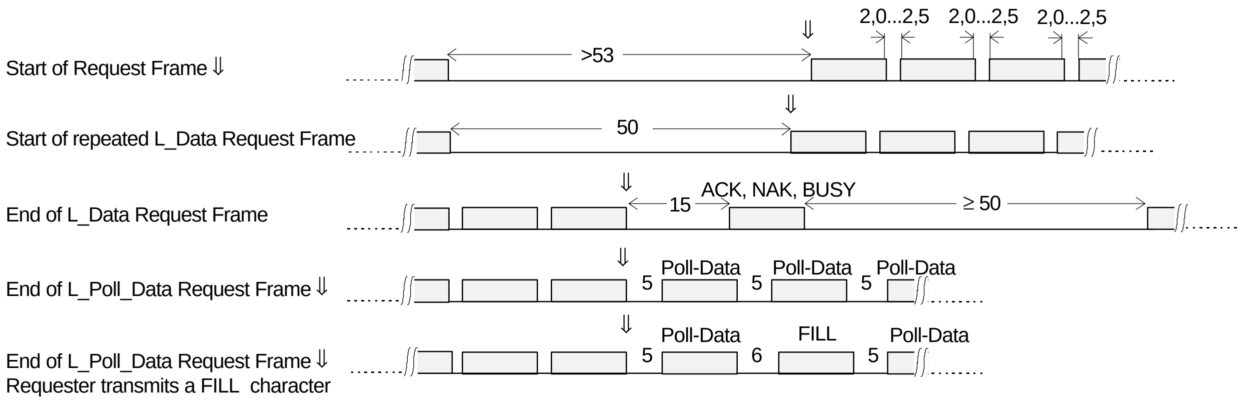

Fig. 3/2/1-36: Character Timing

Due to the fact that a logical ´0´ value is dominant, frames having more leading zeros obtain a higher priority versus frames with less leading zeros, if their transmission starts at the same time. CSMA/CA means that a frame with higher priority will not be disturbed by transmission attempts of lower priority.

After line busy detection and after a collision, the device shall wait until the end of the message cycle in progress and make another attempt to transmit the data link request PDU after 50 bit times or more line idle time.

2.3.1 Overview: Priority Operation Algorithm of the Medium Access Control

Fig. 3/2/1-30 shows the class parameter and the repeat flag contained in the control field of the L_Data request frame. The class parameter has an impact on the priority of a request frame especially in EIB networks with a lot of traffic. System priority is reserved for the data link layer. Alarm, high and low priority may be chosen by the data link layer user; see the group objects and the EIB objects described in Chapter 3/4/1 "User Layer" for more details how to do that. Semantic definitions about the occasions when alarm, high and low priorities should be used are left to an EIB profile.

50 bit times line idle	L_Poll_Data request frame or L_Data request frame with system or alarm priority or repeated L_Data request frame	
	WP	non-repeated L_Data request frame of high or low priority

---> Time

WP = 3 bit times (waiting period)

Fig. 3/2/1-37: Priority Operation

The repeat flag is reserved for the data link layer.

Repeated and non-repeated L_Data request frames having system or alarm priority and repeated L_Data request frames with high and low priority may be sent immediately after 50 bit times line idle time. Non-repeated L_Data request frames of high and low priority shall wait additionally for at least three further bit times.

L_Poll_Data request frames exist only in a non-repeated version.

2.3.2 Priority Sequence

If two data link layer instances detect 50 bit-times line idle at exactly the same time then in case of colliding data link request frames the following priority sequence holds true (in descending order of priority):

control field	data link frame type	class	repeat flag	class available to data link layer user
1001 0000	L_DATA request	system priority	repeated	no
1011 0000	L_DATA request	system priority	not rep.	no
1111 0000	L_POLLDATA request	system priority	not rep.	no
1001 1000	L_DATA request	alarm priority	repeated	yes
1011 1000	L_DATA request	alarm priority	not rep.	yes
1001 0100	L_DATA request	high priority	repeated	yes
1011 0100	L_DATA request	high priority	not rep.	yes
1001 1100	L_DATA request	low priority	repeated	yes
1011 1100	L_DATA request	low priority	not rep.	yes

Fig. 3/2/1-38: Priority Sequence, in Descending Order of Importance

2.3.3 Additional Requirement: Guarantee of Access Fairness

The twisted-pair medium access control algorithm is designed to reduce the number of frame collisions sent by partner devices connected to the same EIB line. Therefore the overall priority sequence behavior described above shall be readjusted in that way that from system point of view no burst behavior shall occur exactly after the end of the 50 bit times line idle time. Therefore in the implementation provisions shall be made to prevent from devices accessing the medium always exactly after 50 resp. 53 bit times. The main intention shall be laid upon fairness between all devices accessing the medium: an equal distribution of medium accesses shall be guaranteed.

Note: Provided that there is no configuration error in the EIB network (i.e. the physical addresses shall be unique), once the source address of a data link request frame is transmitted all collisions shall be resolved.

2.4 Data Link Layer Services

The data link layer can either be in Normal Mode or in Bus Monitor Mode. In Normal Mode the remote L_Data service, the remote L_Poll_Data service and the local L_Service_Information service are available to the data link layer user. In Bus Monitor Mode only the local L_Busmon service is available. The data link layer mode is a parameter of layer-2.

2.4.1 L_Data Service and Protocol

The L_Data service is an acknowledged datagram service. If the local user of layer-2 is preparing an LSDU for the remote user it applies the L_Data.req primitive to pass the LSDU to the local layer-2. The local layer-2 accepts the service request and tries to send the LSDU to the remote layer-2 with frame format 1. The destination address may be a physical address or a group address (multicast or broadcast). The local layer-2 passes a L_Data.con primitive to the local user that indicates either a correct or erroneous data transfer.

Prior to passing the confirmation to the local user, the local layer-2 needs an acknowledgment from the remote layer-2 (frame format 2). If the acknowledgment is a positive acknowledgment (ACK), the local layer-2 passes a L_Data.con with l_status = ACK to the local user. If the acknowledgment is BUSY, the local layer-2 tries to repeat after at least 150 bit times line idle for up to busy_retry times. If BUSY comes back for more than busy_retry times, the local layer-2 passes an L_Data.con with l_status = not_ok to the local user. In all other cases, i.e. acknowledgment is NAK or invalid/corrupted or time-out after 30 bit times, the local layer-2 repeats after 50 bit times up to nak_retry times. If for more than nak_retry times either a NAK or a corrupted acknowledgment comes back or an ack timeout occurs, the local layer-2 passes a L_Data.con with l_status = not_ok to the local user.

The parameters nak_retry and busy_retry are parameters of layer-2. In the maximum, the same request LPDU is transmitted (nak_retry + busy_retry + 1) times, before the data link layer stops retransmission.

If the destination address of a request frame corresponds to the own physical address or to one of the group addresses contained in the EIB end device's address table then the receiver of a data link request frame is addressed. Otherwise the receiver shall discard the received request frame and the subsequent acknowledgment frame.

If the request frame received is not correct (see 2.5.1), the remote layer-2 shall send a NAK character. If the request frame received is correct but the remote layer-2 doesn’t have resources to process it, the remote layer-2 shall send a BUSY character. If the request frame received is correct, the remote layer-2 shall send an ACK character. Furthermore, in case of a correctly received request frame, the LSDU shall be given with an L_Data.ind primitive to the layer-2 user if it hasn't already been received correctly before. To prevent a duplication an already correctly received L_Data request frame shall be acknowledged and discarded.

L_Data.req(destination_address, DAF, class, l_sdu)

destination_address:	either a physical address or a group address
DAF:	destination_address flag indicates whether destination_address is a physical or a group address
class:	system, alarm, high or low priority
l_sdu:	this is the user data to be transferred by layer-2

L_Data.con(l_status)

l_status: OK;	request frame sent successfully
not_ok;	transmission of the request frame didn’t succeed

L_Data.ind(source_address, destination_address, DAF, class, l_sdu)

source_address:	physical address of the EIB end device that requested the L_Data service
destination_address:	the physical address of this device or a group address of this device
DAF:	destination_address flag indicates whether destination_address is a physical (‘0’) or a group address (‘1’)
class:	system, alarm, high or low priority
l_sdu:	this is the user data that has been transferred by layer-2

Note: In the sense of the EIB transport layer a negative L_DATA.con means either a connection-oriented or a connection-less message. In case of an untransmitted connection-less message it is left to the user application how to handle that. In case of an untransmitted communication-oriented message the transport layer attempts further three times to transmit the corresponding T_DATA request PDU. A fourth negative L_DATA.con leads to an abort of the transport layer connection.

2.4.2 L_Poll_Data Service and Protocol

The L_Poll_Data service is a confirmed multicast service. The local user of layer-2 is applying the L_Poll_Data.req primitive to request data from one or more remote users. The local layer-2 accepts the service request and tries to send the L_Poll_Data.req to the remote layer-2 with frame format 3. The destination address is always a poll group address. The poll group address is a parameter of layer-2.

L_Poll_Data request frames that are not correctly received (see 2.5.1) shall be discarded.

After receiving a correct L_Poll_Data request frame with a poll_group_address equal to its own poll group address, the remote layer-2 responds with a single Poll_Data character, see 2.2, frame format 4. The remote layer-2 gets the Poll_Data octet from its user with the L_Poll_Update.req primitive. The Poll_Data character shall be transmitted in the response slot associated with this device. The device's response slot is a defined time slot in which the Poll_Data slave device shall transmit the Poll_Data character. The duration of a response slot is an idle time of 5 times followed by a single UART character. If e.g. a device has the third response slot then the device has to wait for two Poll_Data characters transmitted by other devices, until the device is transmitting its Poll_Data character in the third response slot (see also Fig. 3/2/1-36). The response slot number is a parameter of layer-2.

A device shall not respond if its response slot number is larger than the number of expected poll data (no_of_expected_poll_data) in the request frame.

The local layer-2 expects a number of Poll_Data characters from the poll group. If an expected Poll_Data character has not started after five bit times the local layer-2 is sending a FILL (FEh) after six bit times. The remote layer-2 can therefore still count Poll_Data characters even if a member of the poll group doesn't respond.

The local layer-2 passes a L_Poll_Data.con primitive to the local user that contains the received Poll_Data and FILL octets or an information that the service failed.

The L_Poll_Data Service can only be applied between EIB end devices on a single physical segment. The number of expected Poll_Data characters is limited to 16.

```
L_Poll_Data.req(destination, no_of_expected_poll_data)

 destination:                 a poll group address

 no_of_expected_poll_data:    number of expected poll data cycles



L_Poll_Data.con(l_status, poll_data_sequence)

 l_status: OK;                valid poll_data_sequence

           not_ok;            invalid poll_data_sequence, i.e. collision
                              occurred during transmission of a FILL, or
                              at least one Poll_Data not correct

 poll_data_sequence:          sequence of Poll_Data octets and FILL octets
```

`L_Poll_Update.req(Poll_Data)`

Poll_Data:	The value of the Poll_Data octet to be transmitted in the L_Poll_Data_Response frame.

L_Poll_Update.con()	Indicates that the L_Poll_Update.req has been accepted by the local layer-2.

2.4.3 L_Busmon Service

The L_Busmon service is a local data link service available only in data link bus monitor mode. It consists of the L_Busmon.ind primitive that transfers each received frame from the local layer-2 to the local layer-2 user.

`L_Busmon.ind(l_status, time_stamp, lpdu)`

l_status:	information whether a frame error, bit error or a parity error was detected in the received frame. Additional information about the number of already received frames may also be contained.
time_stamp:	timing information, when the start bit of the frame was received
lpdu:	all octets of the received frame

2.4.4 L_Service_Information Service

The L_Service_Information service is a local data link service available in data link normal mode. It consists of the L_Service_Information.ind primitive.

L_Service_Information.ind()	a frame was received which contained the physical address of the local layer-2 as source address.

2.5 Data Link Layer Protocol

The data link layer's task is to offer a reliable datagram service between devices at the same line. This means that corrupted frames shall be retransmitted (i.e. repeated) for a sensible number of times, that only information of correctly received frames is presented to the data link layer user and that this information is not presented several times to the data link user (duplication prevention).

Clauses 2.2.4, 2.4.1, 2.4.2 and 2.6 contain certain aspects of the data link layer protocol. The following sub-clauses explain additional protocol requirements to be fulfilled by each layer-2 protocol instance.

2.5.1 Checking for Correct Request Frames

If the destination address of a request frame corresponds to the own physical address or one of the group addresses of an EIB end device, then the receiver of a data link frame shall check whether the frame is correct. A frame is correct if:

- every UART character has a correct start/stop bit (otherwise: framing error) and parity bit (otherwise: parity error)
- every bit of a UART character has a correct signal timing (otherwise: bit error)
- the check octet has the correct value
- the control field has a correct value
- the length of the frame is between seven and 23 characters.

2.5.2 Consequences of Priority Operation and Fairness for Duplication Prevention

Fig. 3/2/1-38 shows that a repeated low priority L_Data request frame is less prior as e.g. a non-repeated alarm priority L_Data request, provided that data link layer line idle detection occurs at the same time.

This implies that if an ACK to a non-repeated low or high priority request frame is corrupted and another device at the same line at the same time has to transmit an alarm priority L_Data request to the ACKing device, then the ACKing device might lose the knowledge, that the subsequent repeated low or high priority frame is a duplicate.

Informal rules to remedy that:

- Reduce noise at the medium as much as necessary to avoid corrupted ACKs.
- Otherwise: Do not use many alarm priority frames and
- Be aware during internal or external user application programming of the possibility that in rare cases a duplicated L_Data service may occur.

2.6 State Machine of Layer-2

After power on, a device doesn't receive or transmit frames. The layer-2 state machine (Fig. 3/2/1-39) is using the Ph_Reset to synchronize with the start of request frames of a possibly existing network. With the positive confirmation Ph_Reset.con(+) the layer-2 state machine is in the idle state where layer-2 shall work as described in the clauses above, i.e. receive frames and transmit frames. However if the physical layer indicates a transceiver error either with a Ph_Reset.con(-) or with a Ph_Data.con(-), the layer-2 shall perform the transition into the Off_Bus state, where no frames shall be transmitted any more. Only a power on can make the layer-2 state machine leave the Off_Bus state. In Off_Bus state every data link request shall be negatively confirmed. Additionally the transmitter shall be switched off.

The data link layer shall store in non-volatile memory when a transition to Off_Bus state did occur. The location for this information shall be the 'stuck flag', see Volume Three, Part One, Layer-8. The stuck flag may be reset by a configuration tool.

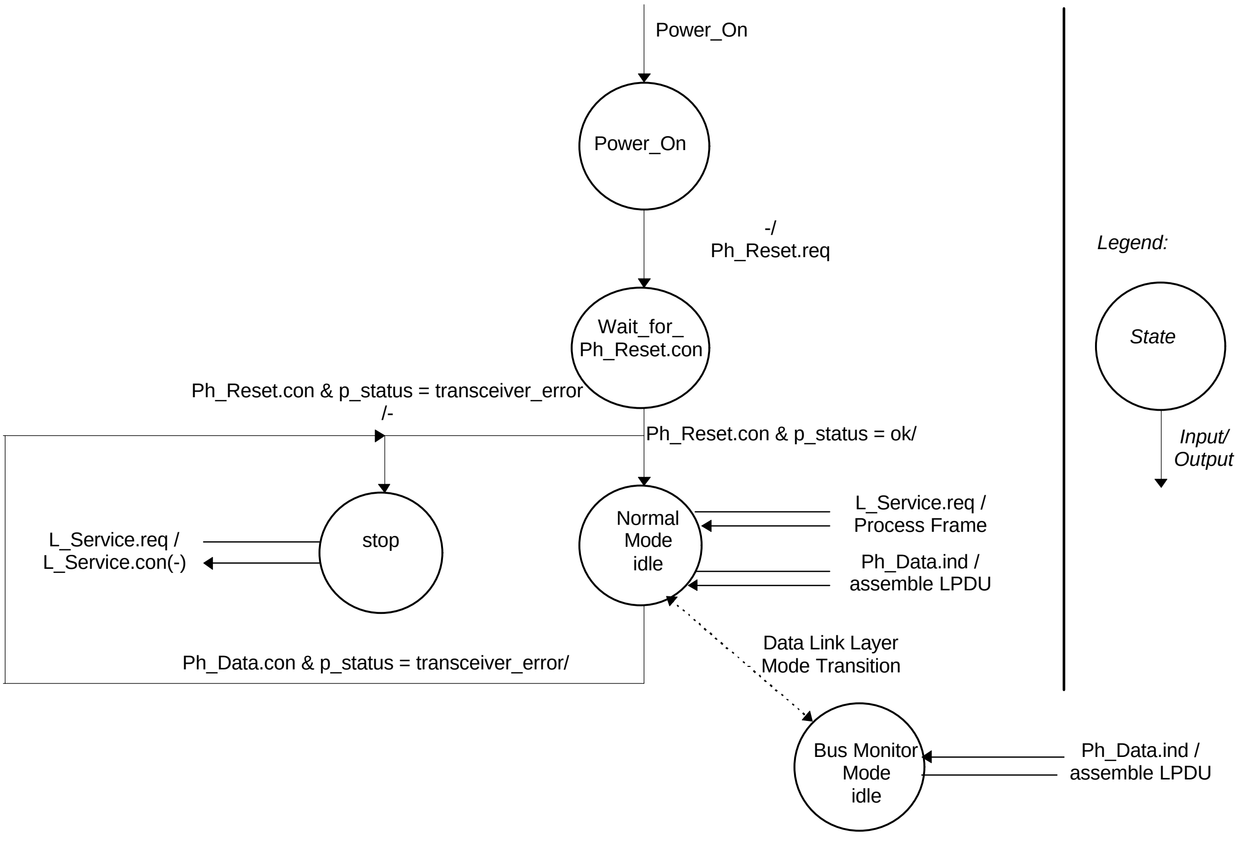

Fig. 3/2/1-39: State Machine of Layer-2

2.7 Parameters of Layer-2

The following parameters influence the behavior of layer-2 and are required inside layer-2 in order to operate correctly:

physical address	unique physical address of this device
address table	address table with the group address(es) of this EIB end device
nak_retry	defines the number of retries in case of a NAK response or a acknowledgment timeout
busy_retry	defines the number of retries in case of a BUSY response
poll group address	the poll group address of this EIB end device
response slot number	the response slot number of this EIB end device
data link layer mode	either the normal or the bus monitor mode of the data link layer.

2.8 Reflections on the System Behavior in Case of L_Poll_Data Configuration Faults

The following L_Poll_Data misconfigurations potentially can be done:

- *Two L_Poll_Data masters belong to the same polling group:*

  Misconfiguration remains hidden unless someone at the bus monitor detects that the same polling group is used in two L_Poll_Data service requests with different source addresses.

- *Two Poll_Data slaves of the same polling group have the same Poll_Data response slot number:*

  In case both slaves transmit the same Poll_Data character value nothing irregular happens. If the values differ, the Poll_Data response with an earlier dominant bit will force collision avoidance at the other Poll_Data slave, so that the latter Poll_Data slave will not be able to transmit its response.
  Indirectly this kind of misconfiguration is detectable because at another slot an expected L_Poll_Data character will never appear.

- *Poll_Data slave illegally transmits a FILL character:*

  At the master side this will be interpreted as a missing Poll_Data slave and is therefore detectable easily.

2.9 The Layer-2 of a Bridge

A bridge doesn’t need a physical address. A physical address of a bridge may be used to set manufacturer specific parameters in the bridge.

A bridge has a layer-2 that responds to all L_Data request frames independent from the value of the destination address and transmits the L_Data request to the other side. All other layer-2 services are ignored.

2.10 The Layer-2 of a Router

A router has a layer-2 that responds to a L_Data request frame if the value of the destination address

- is listed in the routing_table (see Volume Three, Part One, Layer-3)
- or if the destination address is a physical address that indicates that the destination is on the other side of the router
- or is equal to the physical address of the router.

In these cases, the L_Data.ind is indicated to the layer-3. All other layer-2 services are ignored.

2.11 Externally Accessible Bus Monitor and Data Link Layer Interface

The data link layer services can be made available to an external user application. See Chapter 3/6/3 "External Message Interface", clause "Bus Monitor EMI" for the L_Busmon external message format, clause "Data Link Layer EMI" for the normal mode data link layer external message formats and clause "Layer Access Management" how to switch between bus monitor and data link layer mode.

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