10BASE-T1S Sleep/Wake-up Specification

Sleep/Wake-up Specification for Automotive Ethernet

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Abbreviation/Symbols

CSMA/CD	Carrier Sense Multiple Access with Collision Detection
DME	Differential Manchester Encoding
DUT	Device Under Test
MAC	Media Access Control
MDI	Media Dependent Interface
MII	Media Independent Interface
PCS	Physical Coding Sublayer
PHY	Physical Layer
PLCA	Physical Layer Collision Avoidance
PM	Power Management
PMA	Physical Medium Attachment
PMIC	Power Management Integrated Circuit
pt-pt	Point to point
INH	Inhibit
I/O	Input/Output
OTP	One Time Programmable
RS	Reconciliation Sublayer
SMI	Serial Management Interface
SoC	System on Chip
VBAT	Battery Voltage
WUP	Wake-Up Pulse
WUS	Wake-Up Sleep
WUT	Wake-Up Tone
+	May indicate either the arithmetical sum operation or the logical OR function
*	May indicate either the arithmetical multiply operation or the logical AND function

1 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.
ISO and IEC maintain terminological databases for use in standardization at the following addresses:
— ISO Online browsing platform: available at https://www.iso.org/obp
— IEC Electropedia: available at http: //www.electropedia.org/

— Node term definition:

End Node	A node that is at either end of a mixing segment. There are no other nodes between the End Node and the 100Ω edge termination. The End Node may contain the 100Ω edge termination.
Drop Node	Any node that is located between the two end nodes
Coordinator	This is the node configured as aPLCALocalNodeID=0 that is responsible for the periodic transmission of the BEACON and configuring the number of transmit opportunities between each BEACON.
Follower	Followers are any nodes configured as aPLCALocalNodeID=1..254. They synchronize their transmit opportunity counter with the reception of the periodic BEACON transmitted by the coordinator
Head Node	This is the highest-level application node on the mixing segment. It typically implements a switch or gateway access to the core network beyond the bus segment.

Note: It is expected that each network segment includes one Coordinator Node, one Head Node, and two End Nodes. The Coordinator and Head Node functions may be implemented in any physical node (including End Nodes) and may be combined into a single physical node or separate physical nodes.

— Network segment states:

Quiet Link Segment	A 10BASE-T1S network segment in which there is no activity on the physical medium.
Partial Link Segment	A 10BASE-T1S network segment with at least one node transmitting on the physical medium. (Including PLCA beacons)

— Wake-up/Sleep : In the context of this specification the term “Sleep” indicates entry to low power state and the term “Wake-up” indicates the exit from a low power state.

— State diagrams follow the conventions outlined in section 147.1.3.1 of [1].

2 Normative references

The following documents are referred to in the text in such a way that some or all their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

[1] IEEE 802.3cg Task Force, "IEEE Std 802.3cg™-2019, Amendment 5: Physical Layer Specifications and Management Parameters for 10 Mb/s Operation and Associated Power Delivery over a Single Balanced Pair of Conductors," IEEE Standards Association, New York, 2019.

3 Introduction

This specification defines a Power Management (PM) Client and associated primitives and functions to support a controlled link shutdown and a fast global wake-up within an Ethernet network. Higher layers like the network management can access those service primitives through the PM Client to realize partial networking, where selected parts of a network are inactive. The coordination of switching off selected nodes of a network is handled by the network management and is not part of this specification. This partial networking concept relying on selective link shutdown and fast global wake-up is especially suited for automotive Ethernet networks.

3.1 Relationship to IEEE 802.3cg specification [1]

The IEEE 802.3cg – 2019 specification [1] does not define mechanisms for a controlled 10BASE-T1S link segment shut-down and wake-up. Therefore, the new PM Client and service primitives defined in this specification can be regarded as a supplement to the 802.3cg-2019: 10BASE-T1S specification [1].

The new PM Client makes use of the Wake-Up Pulse (WUP) command. When not using the new PM Client, service primitives, and commands, implementation of these extensions will not impact the interoperability to a “basic” 802.3cg-2019 [1] : 10BASE-T1S PHY.

4 Scope

The following are the objectives of the Sleep/Wake-up specification:

1. Shall comply with the CSMA/CD MAC
2. Shall support wake-up process completely covered in OSI layer 1
3. Shall comply with standard media interface specifications such as xMII (MII, RMII, RGMII etc.)
4. Shall comply with Autosar network management
5. Shall support half duplex pt-pt, multidrop with PLCA, multidrop without PLCA, a combination of PLCA and non PLCA nodes and should support full duplex pt-pt
6. Shall support signaling to wake-up all nodes on the 10BASE-T1S segment (Segment wake-up)
7. Shall define the latency associated with PHY level wake-up
8. Shall include TC10 standard wake forwarding mechanisms
9. Should facilitate segment that contains a mixture of low power and non-low power nodes on an active T1S segment (Partial networking)
10. Should allow any node on the segment to request network wake-up
11. Shall support physical partitions with separate Transceiver (AFE) and integrated solutions.

5 Wake-up Electrical Interface

PHYs supporting wake-up signalling over dedicated I/O pins should follow the following guidelines. Wake-up commands are not part of the xMII interface.

The following list shows examples of pins typically associated with wake-up functionality. Depending on the type of device and functionality not all pins are relevant.

Figure 5-1—Example of wake-up related device pins

Pin name	Direction[1]	Function	Voltage Source	Mandatory
INH	OUT (Wired- OR)	Prevent external regulator from shutdown	VDD_AO	Recommended [2]
LOCAL_WAKE	IN	Local wake input	VDDIO[3] or VDD_AO	Head node : Yes[4] Non-head node : No
WAKE_FWRD	OUT	Wake	VDDIO or VDD_AO	No
WAKE_IN_OUT	IN/OUT (Wired-OR)	Multiplex interface to support wake input and output over the same pin	VDDIO or VDD_AO	No[5]
VDD_AO	IN	Always-on supply, available during low power to power wake-up detection functionality	VBAT or other available standby supply	Yes

[1] From the perspective of the DUT
[2] INH is not necessarily supported through the AFE partitioning and would become an ECU recommendation in this configuration
[3] Standard JEDEC voltage level recommended; no specific voltage level given in this spec
[4] LOCAL_WAKE is not necessarily supported through AFE partitioning and would become an ECU requirement in this configuration
[5] WAKE_IN_OUT can optionally be used to replace dedicated LOCAL_WAKE and WAKE_FWRD and merge the functionality into a single pin.

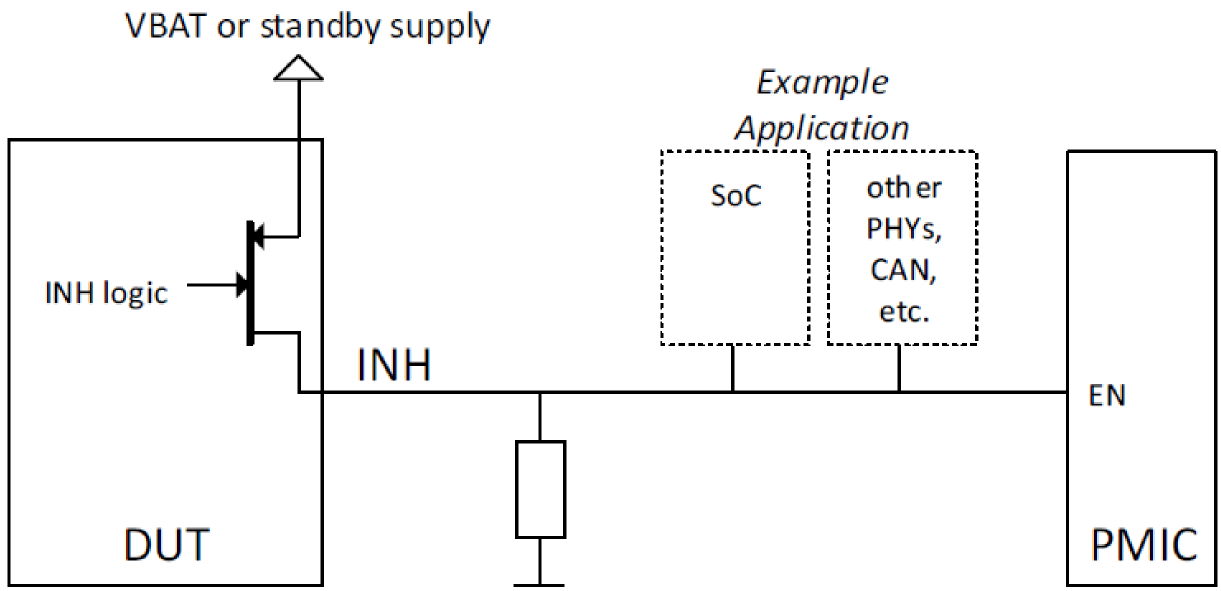


Figure 5-2--INH topology and example application

The interface shall support a local-wake-up input on head nodes and optionally on non-head nodes, additionally it may support a wake-up-forwarding output. For multi PHY designs these pins can be joined. Inhibit pins should be a high-side switch, which is pulling INH high during normal operation and high-Z during low power. A dedicated wake-up-forwarding pin must be active-high.

The I/O voltage is left to the implementer. Note that INH is supplied by a standby or permanent VBAT supply which is available during low power mode.

In some automotive use-cases unwanted glitches may be coupled onto the LOCAL_WAKE pin. In order to mask these glitches in such applications it is required to implement a detection threshold. Pulses with a duration of less than 10 us must not be detected as wake-up event and are to be ignored. A pulse duration of more than 40 us must be guaranteed to be detected and cause a wake-up. Note that pulses in this interval are undefined.

From this follows that a local wake-up output pulse (originating from WAKE_IN_OUT, WAKE_FWRD or another source) must have a duration of at least 40 us to be reliably detected.

In case LOCAL_WAKE is fed through the wiring harness (support for slow legacy wake-up line) it is recommended to have the option to increase the rejection window (minimum of 10 ms).

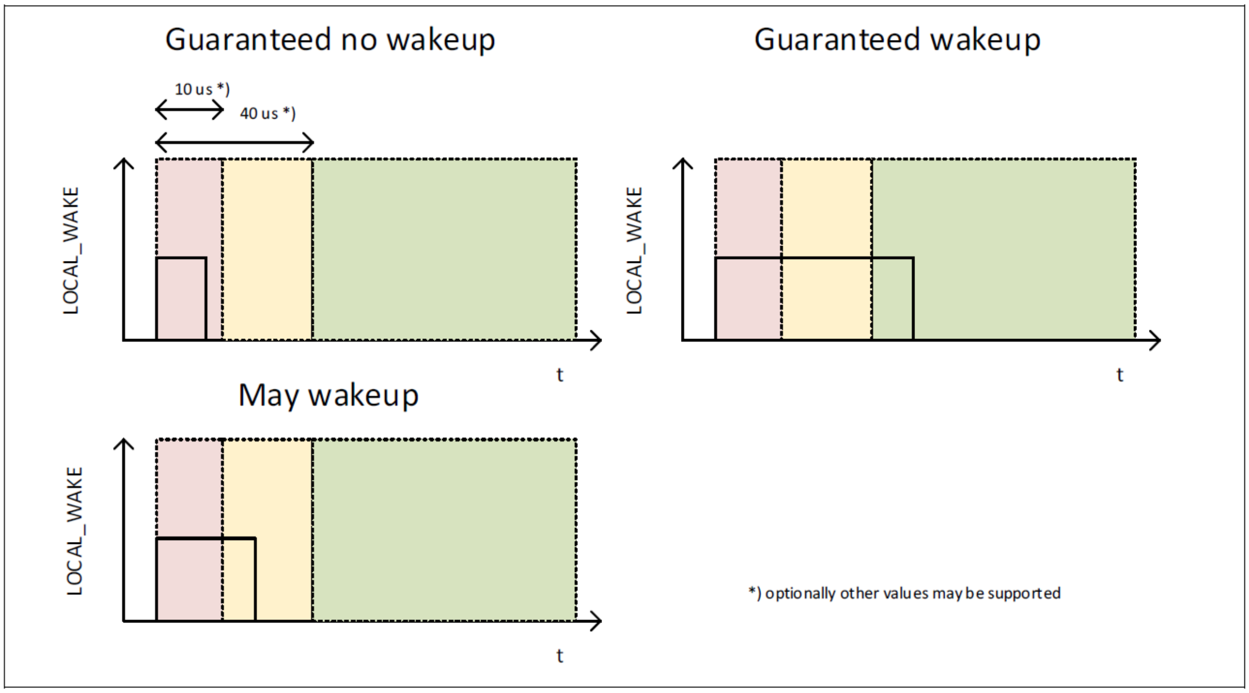


Figure 5-3--LOCAL_WAKE glitch rejection timing diagram

6 Power Consumption

The following guidelines on the device power consumption in low power mode target typical Ethernet products such as single and multiport PHYs and switches.

A single-port PHY product or a separate Transceiver implementation should have a quiescence current of 35µA. A multi-port PHY or switch product should have a quiescence current of 25µA plus 10µA for each port[6].

7 Timing Behavior

The low power entry and wake-up process in a PHY shall fulfill the following requirements[7]:

Table 7-1--Low power entry, exit, and forward timing requirements

	Min	Typ	Max	Units
LOW_POWER_timer	-	-	2	ms

[6] More complex SoC products with other wake-up-capable interfaces may exceed these numbers, while still meeting this specification. Quiescent current examples shall be understood as design targets under the assumption of typical temperatures while vehicles are parked for a longer time (e.g., limited to 85°C or below)
[7] For the mentioned timer values a 10 % tolerance is expected.

TWU_Start_quiet	-	-	2	ms
TWU_Start_partial	-	-	TWU_Start_quiet (max) + maxPLCACycleTime	N/A
TWU_Detection	-	-	2	ms
TWU_Indication	-	-	17	ms
TWU_Forwarding	-	-	1	ms
TWU_Forwarding_Indication			10	us
TWU_WakeIO	-	-	1	ms

7.1 LOW_POWER_timer

The maximum allowed time for a PHY node or SWITCH to transition to LOW_POWER state from when a LowPowerEntryLocal.Request is received shall be less than LOW_POWER_timer. Expiration of the LOW_POWER_timer shall be indicated via LowPowerEntryLocalFail.indication.

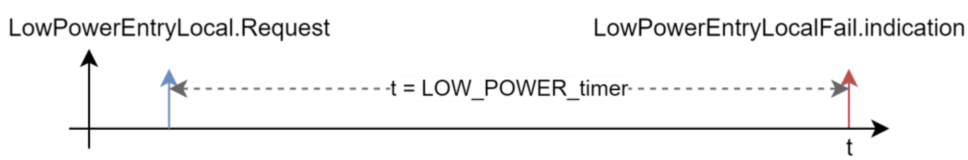


Figure 7-1--LOW_POWER_timer diagram

7.2 TWU_Start_quiet

The maximum allowed time for a PHY node or SWITCH node to commence transmission of WUP on a quiet network segment from when a Wakeup.request or WakeupForward.request is received shall be less than TWU_Start_quiet. Note this time assumes that the device requested to transmit the WUP is not in a low power state. The boot time of devices in low power state is outside the scope of this specification.

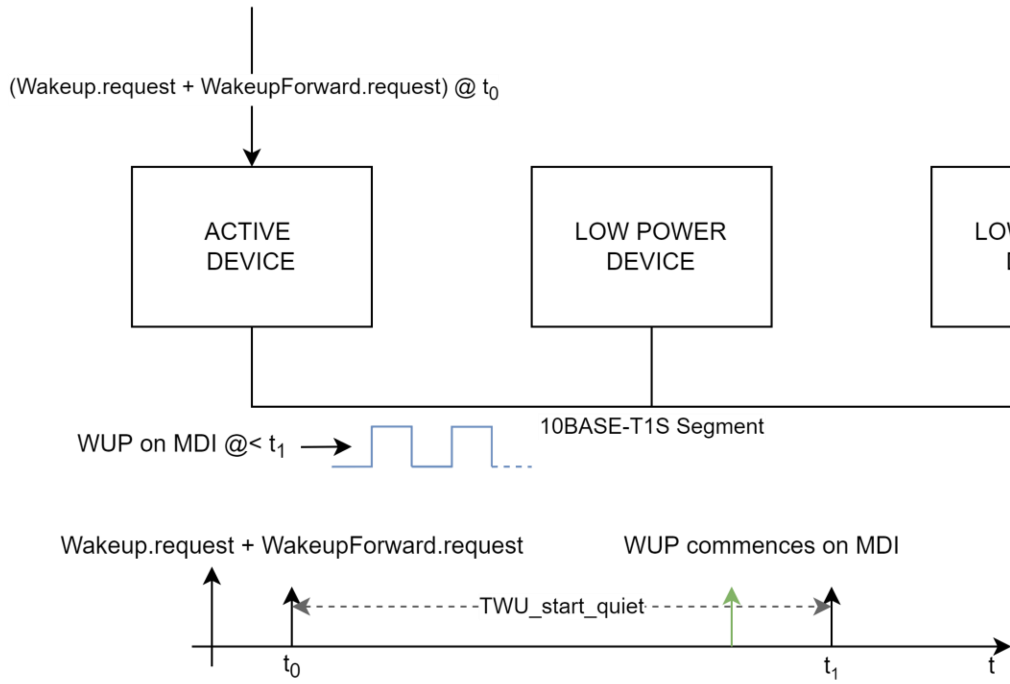


Figure 7-2--TWU_Start_quiet diagram

7.3 TWU_Start_partial

The maximum allowed time for a PHY node or SWITCH to commence transmission of WUP on a partial network segment from when a Wakeup.request or WakeupForward.request is received shall be less than TWU_Start_partial. A node operating in PLCA mode with plca_status = OK transmits the WUP during the node's transmit opportunity. This case sets the maximum allowed time which is:

TWU_Start_partial < TWU_Start_quiet (max) + maxPLCACycleTime

maxPLCACycleTime is measured in seconds and is computed as follows:

$$maxPLCACycleTime = \{\sum_{i=1}^{aPLCANodeCount}(aPLCAMaxBurstCount(i) * ((MAX\_FRAME\_SIZE(i) * bit\_time) + IPG(i) + MDI\_input\_to\_CRS\_deasserted(i))\} + beacon\_timer$$

where

MAX_FRAME_SIZE is the maximum frame size supported by the node, measured in bits, and is calculated as

MAX_FRAME_SIZE = maxFrameSizeLimit * 8

And all other variables are defined in [1]

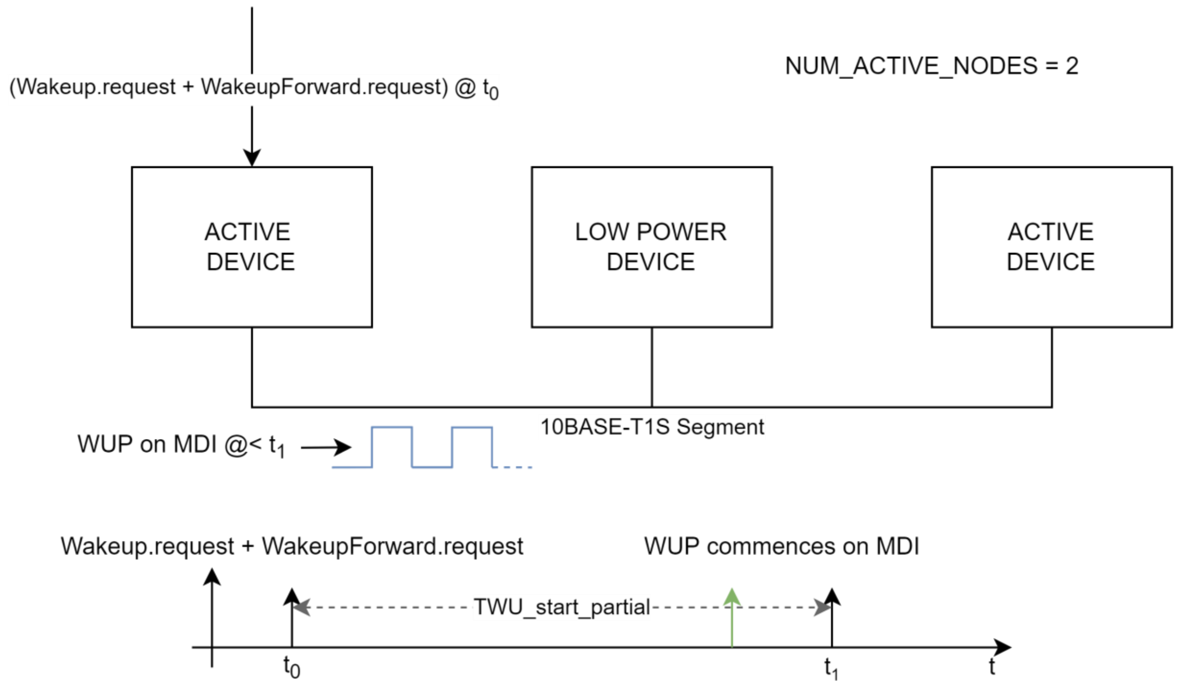


Figure 7-3--TWU_Start_partial diagram

7.4 TWU_Indication

The maximum allowed time for Wakeup.indication to be asserted by a device initially in low power state from when WUP transmission commenced on the network segment shall be less than TWU_Indication. The TWU_Indication is

TWU_Indication < TWU_Detection + T_Powersupply_stable + T_Initalization

The maximum allowed time for detection of a valid WUP on the MDI shall be less than TWU_Detection.
T_Powersupply_stable is the time from when the device requests power until the power supply is stable.
T_Initialization the time from when the power supply's stable voltage is reached until Wakeup.Indication is generated.

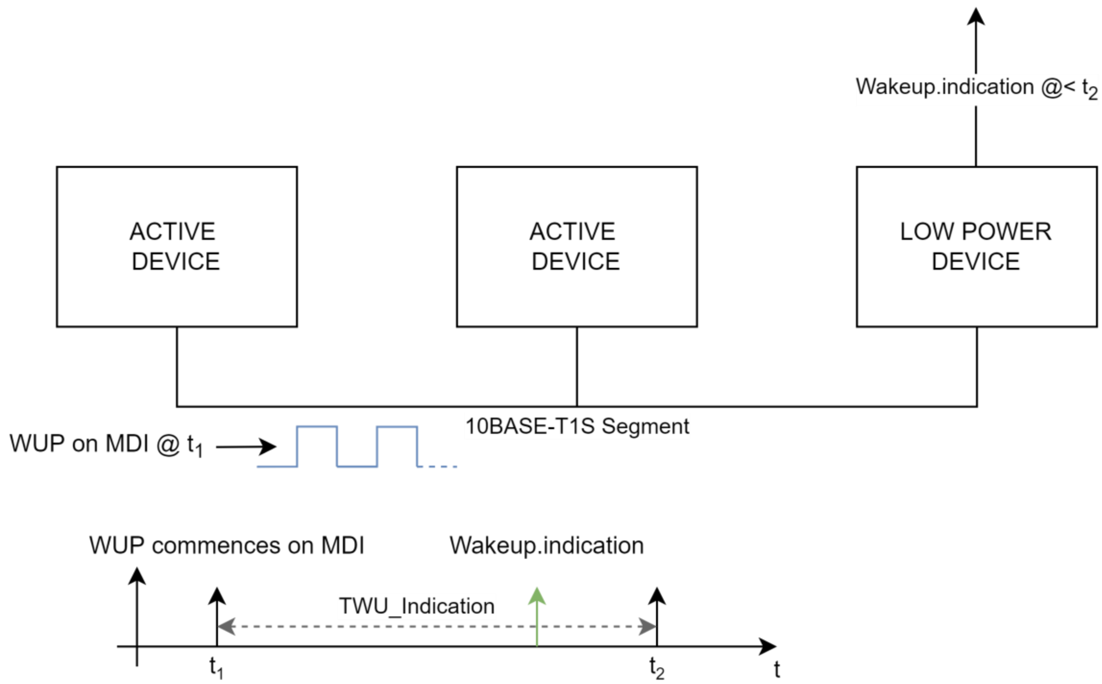


Figure 7-4--TWU_Indication diagram

7.5 TWU_Forwarding

For multiport devices it is possible to forward a wake-up from one physical port to another physical port. TWU_Forwarding is the time from receiving a wake-up WakeupForward.Indication on one physical port until a WakeupFoward.Request is generated on another physical port.

7.6 TWU_Forwarding_Indication

TWU_Forwarding_Indication is the time from receiving a Wakeup.request or Wakeup.indicaiton to generation of a WakeupForward.Indication.

7.7 TWU_WakeIO

The time TWU_WakeIO is defined from the generation of a Wakeup.request in one device to the reception of the corresponding Wakeup.indication in the other device when both devices are connected by using the electrical wake-up interface pins (for instance WAKE_FWRD or WAKE_IN_OUT).

8 Power Management Client

8.1 Overview

The optional Power Management Client enables power savings during periods where one or more nodes on the 10BASE-T1S link segment are not required to be operational. It controls the entry of the local PHY into a low power state and the coordinated exit from the low power state of all supporting nodes connected on the link segment.

The communication of the PM Client to higher layers is not specified here. It may be through SMI, the Wake-up Electrical Interface, or other appropriate methods. If an SMI interface is used to control the PM Client then the minimum set of registers defined in section 8.6 shall be supported. The PM Client communicates with the PHY through the RS described in section 148 and utilizes the primitives defined in section 8.2.

Communication of wake-up events between PM Clients is achieved through the WakeupForward primitives. The Wake-up Electrical Interface of section 5 or other appropriate means is used to implement this interface.

The state machine for control of the local PHY power state is described in section 8.4. The command to exit all supporting PHYs on the mixing segment from low power state is described in section 8.3.

8.2 Service Primitives and Interfaces

Besides the service primitives and interfaces, specified in [1], new service primitives are provided by the Reconciliation Sublayer (RS) to the PM Client. These services are needed to realize the low power entry and wake-up behavior.

The low power control information is transferred between the SMI, PM Client, RS, PCS, PMA, and physical device pins.

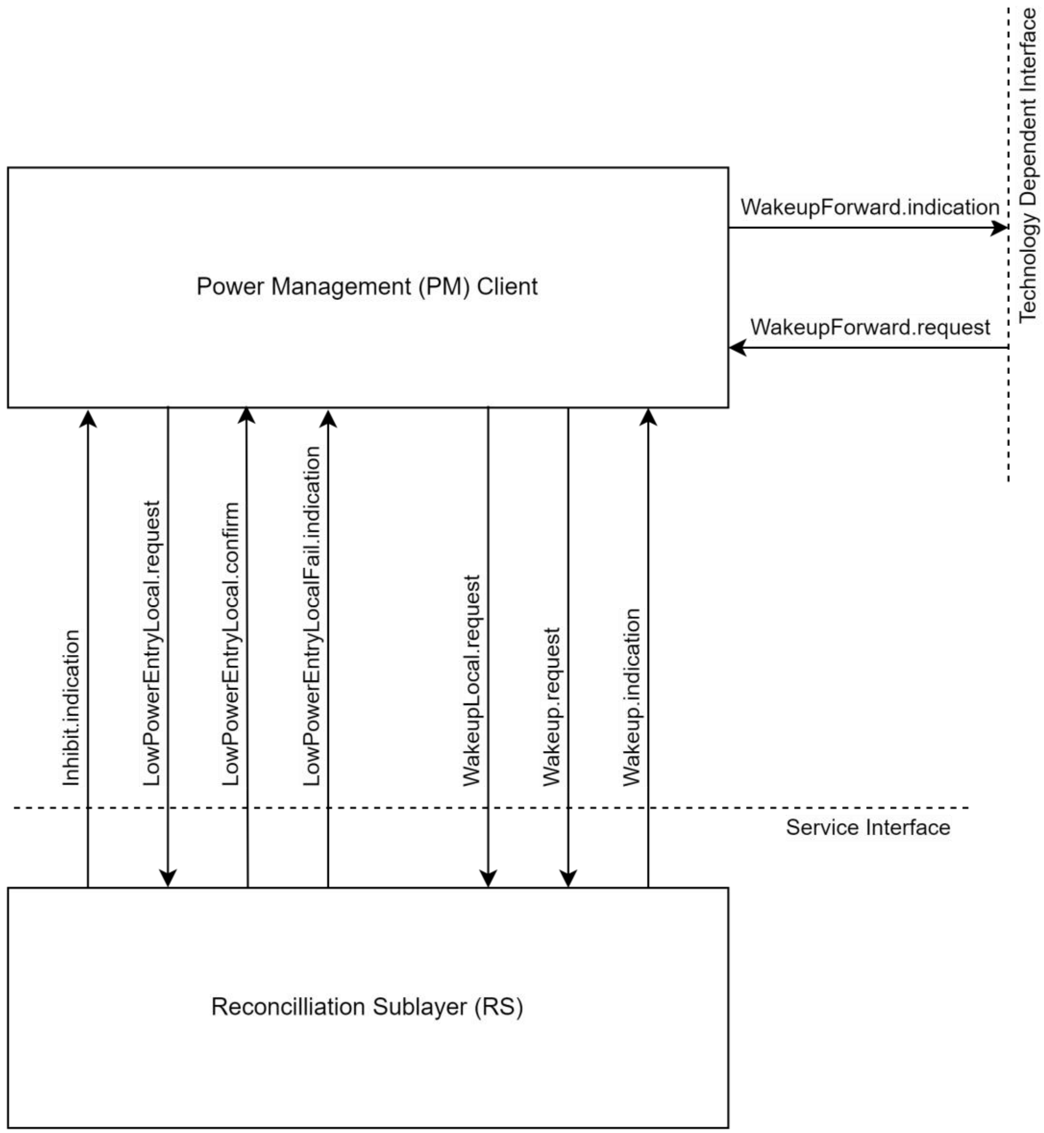


Figure 8-1--Added PM Client and RS interlayer service interfaces

8.2.1 LowPowerEntryLocal.request

The purpose of the *LowPowerEntryLocal.request* service primitive is to shut down the Physical Layer in a controlled manner without corrupting ongoing transmissions on the link segment. The activation of LowPowerEntryLocal.request for the purpose of network power management is the responsibility of the PM Client.

8.2.2 LowPowerEntryLocal.confirm

The purpose of the optional *LowPowerEntryLocal.confirm* primitive is to acknowledge the Physical Layer has successfully entered the low power state.

8.2.3 LowPowerEntryLocalFail.indicaton

The purpose of the optional LowPowerEntryLocalFail.indication is to indicate an unsuccessful attempt to put the Physical Layer into a low power state.

8.2.4 WakeupLocal.request

The purpose of the WakeupLocal.request service primitive is to transition the Physical Layer from a low power state.

8.2.5 Wakeup.request

The purpose of the Wakeup.request service primitive is to request a WUP be communicated to all nodes within the 10BASE-T1S link segment. If the device is in a low power state this primitive infers a WakeupLocal.request followed by a Wakeup.request.

8.2.6 Wakeup.indication

The purpose of the *Wakeup.indication* service primitive is to indicate a detected wake-up event. This includes a wake-up over a network segment as well as over a local wake-up pin.

8.2.7 Inhibit.indication

Signals the state of an optional power supply inhibit interface.

8.2.8 WakeupForward.indication

(optional)
This service primitive signals that a wake-up forwarding event has been received over wake I/O functionality or MDI.

8.2.9 WakeupForward.request

(optional)
This service primitive signals that a wake-up event has been forwarded to this port as a consequence of a WakeupForward.indication on another port or through the wake I/O functionality.

8.3 Command Definitions

This specification defines one command which is used to request a wake-up over a 10BASE-T1S link segment.

8.3.1 Wake-Up Pulse (WUP)

The WUP is a command to indicate a wake-up request to all nodes on the 10BASE-T1S link segment. It can be sent by any node PHY or switch PHY to distribute the wake-up request over a link segment. The command can be sent on either a quiet or partial link segment.

The WUP command is transmitted directly onto the MDI by the 10BASE-T1S PHY. The WUP shall be comprised of a SUSPEND, Wake-Up Tone (WUT), COMMIT, and ESD/ESDOK sections. WUT is polarity independent. It may start with either a low or a high period.

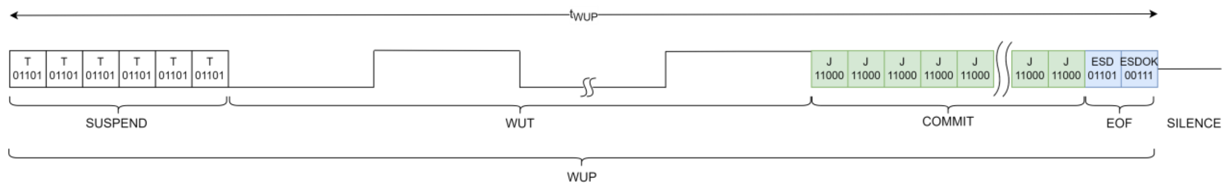


Figure 8-2--WUP Command

The SUSPEND section of the WUP pattern shall be comprised of six, DME encoded T symbols[8]. The timing of constituent SUSPEND symbols should conform to the timing specifications outlined in clause 147 of [1].

The WUT section of the WUP is comprised of 12 periods of a 625kHz tone.

The COMMIT section of the WUP pattern is comprised of 24 to 26 DME encoded J symbols. The timing of constituent COMMIT symbols should conform to the timing specification outlined in clause 147 of [1].

The total length of the WUP shall conform to the timings outlined in Table 8-1—WUP timing. The transmission of the WUP must conform to the timing and electrical specifications of [1] clause 147 including updates to that clause outlined in this document.

Table 8-1—WUP timing

Symbol	Minimum	Typical	Maximum	Units
t_{WUP}	32.0	32.4	32.8	us

All other nodes on the IEEE 10BASE-T1S network segment do not commence any transmissions while a WUP command is active on the MDI.

The detection of the WUP command is left to the implementer.

PHYs with multi-speed capabilities shall use the specified WUP pattern corresponding to the speed the PHY is configured to operate in. The speed configuration process depends on the application and can be set through means of pin-strapping, auto negotiation result, register configuration, OTP fuses or similar.

If WUP is sent prior to auto negotiation results are available, then WUP should be the minimum speed advertised by the auto negotiation.

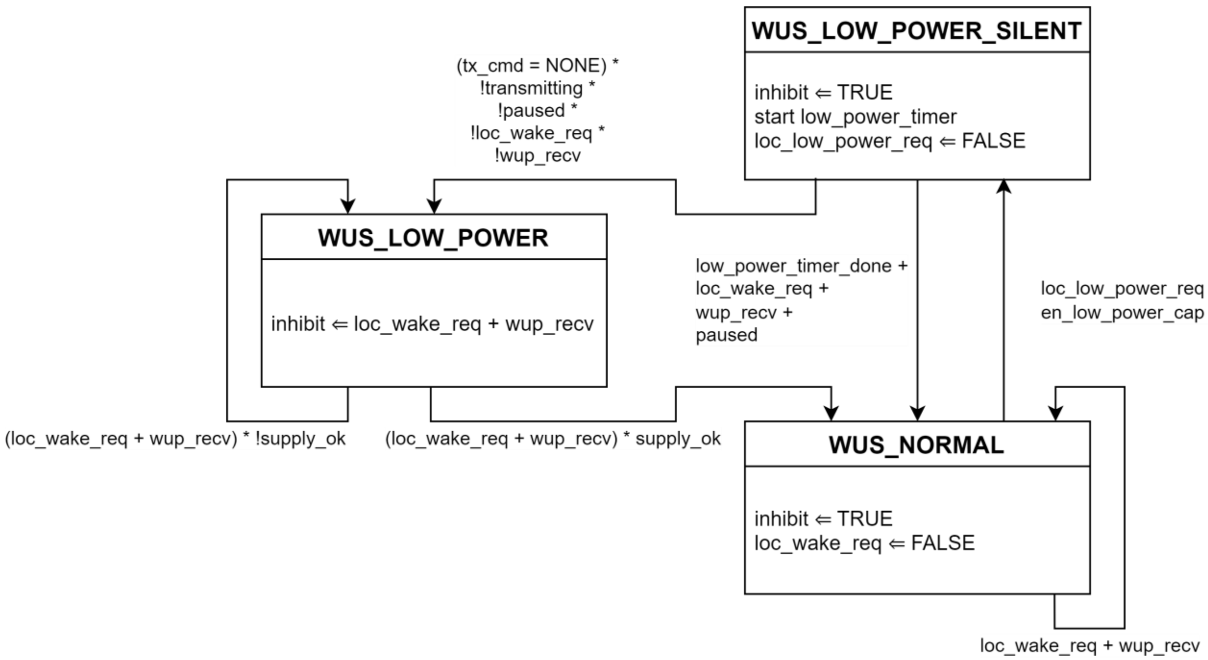
Note, it is only guaranteed that a WUP can be detected reliably if the responder PHY devices supports and operates in the WUP associated speed mode.[9]

[8] T symbol defined in Table 147-1-4B/5B Encoding of [1]

[9] For example, a WUP transmitted by a PHY operating in 10BASE-T1S mode is not guaranteed to be detected by a 100BASE-T1 device and vise-versa.

8.4 PHY power control

The following state diagram shows the power states of a 10BASE-T1S Physical Layer.



[10]

Figure 8-3--PHY power mode state diagram

8.4.1 PHY reset and initialization

After a device reset, the PHY may automatically assert loc_wake_req. This may optionally trigger a WUP transmission on the network segment.

8.4.2 Low Power

In case the PHY is not in WUS_LOW_POWER state and a *loc_low_power_req* is asserted the PHY will enter WUS_LOW_POWER_SILENT state and start the low_power_timer. In the WUS_LOW_POWER_SILENT state the PHY will wait until the PHY has completed all transmissions and no active wake-up requests are detected before transitioning into WUS_LOW_POWER state. The successful transition to WUS_LOW_POWER state may be communicated via the optional LowPowerEntryLocal.confirm primitive. In this WUS_LOW_POWER state only parts of the device required for the detection conditions that result in the transition out of this state are required to be kept active. Other parts of the device may be switched to low power consumption modes. If the conditions for transitioning into WUS_LOW_POWER state are

[10] Cold boot or start up state may be implementation specific.

not met before low_power_timer_done or a wake-up request is received, the PHY transits back to WUS_NORMAL state and may be communicated via the optional LowPowerEntryLocalFail.indication.

8.4.3 Wake-up

In case the PHY is in WUS_LOW_POWER state and a Wakeup.request is detected the PHY will inhibit the power supply from shutting down. Once the power supply is within operating range the PHY will enter WUS_NORMAL power state.

The signaling of a *Wakeup.request* is achieved by transmitting a WUP on the link segment at the appropriate time.

Wakeup.indication shall be asserted upon wake-up events. This service primitive is generated in any of the following cases:

- A valid WUP (wup_recv) is detected over MDI. A valid WUP is defined in 8.3.1.
- A valid local wake-up (loc_wake_req) is asserted.

The WUP detection process is implementation specific. A detected WUT communicated via PMA_WUT.indication may be used as part of this process.

8.4.4 Variables

wup_recv : This variable is set according to the status parameter of the PMA_WUT.indication primitive. When status is DETECTED this variable is set to TRUE. This variable is set to FALSE when the PHY Power Mode state machine enters WUS_NORMAL state.

Values: TRUE or FALSE

loc_low_power_req : This variable is set to TRUE if a low power state is requested by the LowPowerEntryLocal.request service primitive. The variable is set to FALSE when the PHY Power Mode state machine enters WUS_LOW_POWER_SILENT state.

Values : TRUE or FALSE

loc_wake_req : This variable is set to TRUE if a local wake-up is requested by the WakeupLocal.request service primitive. The variable is set to FALSE when the power state controller returns to WUS_NORMAL state.

Values : TRUE or FALSE

inhibit : Set to TRUE if the (external) power supply shutdown is inhibited.

Values : TRUE or FALSE

en_low_power_cap : Set to TRUE if the PM Client is supported by the local PHY, otherwise it is set to FALSE.

Values : TRUE or FALSE

paused : See section 148.4.7.2

supply_ok : Set to OK if PHY power supplies are within the operating range of the device.

Values : OK or ERROR

tx_cmd : See section 148.4.4.2

transmitting : See [1] section 147.3.2.2

8.4.5 Timers

LOW_POWER_timer : See 7.1

8.5 Wake-up-forwarding

Multi-PHY devices (e.g. switches) or PHYs that implement WAKE_FWRD or WAKE_IN_OUT pins shall have a selective wake-up forwarding mechanism. If a multi-PHY device detects a *Wakeup.Request*, it shall be possible to forward the *indication* to one or multiple other PHYs of the device.

A *Wakeup.request* can originate from MDI side (as WUP), from Serial Management Interface (SMI) side (over wake-up register) or over a physical pin (LOCAL_WAKE, WAKE_IN_OUT).

It shall be possible to forward a wake-up from the originating PHY to selectable target 10BASE-T1S network segments. On these target network segments the wake-up is sent over MDI (as WUP)[11].

In case the device implements a WAKE_FWRD or WAKE_IN_OUT pin, a wake-up forwarding shall be indicated by asserting the pin.

8.6 Register controls

This section outlines a minimum set of registers that shall be available if the PM Client supports an SMI interface. Additional implementation specific registers may also be provided. These additional registers are not defined here.

Table 8-2--Register controls

Addr. Name	Addr. Value (HEX)	Bit(s)	Field Name	Access *	Default	Description
WS_STATUS	D000	15	LPCAP	RO	1	PM Client capability
WS_STATUS	D000	14	LP_FAIL	RO	0	Low power entry request status. This bit is cleared when a request to transition to LOW POWER is received.
WS_STATUS	D000	13-0	reserved	RO	0..0	Reserved for future use

[11] In case wake-up events arrive on multiple sources (e.g., pin and MDI) in a short interval, the wake-up event may be joint into a single event.

WS_CTRL	D001	15	LPREQ	SC	0	Request transition to low power on local node
WS_CTRL	D001	14	LPEXIT	SC	0	Request transition from low power on network segment
WS_CTRL	D001	13-0	reserved	RO	0..0	Reserved for future use

* RO = read-only, RW = read-write, SC = self-clearing

9 Modified PLCA, PMA and PCS IEEE802.3cg

The following sections describe the modification of the PHY Level Collision Avoidance (PLCA), Physical Coding Sublayer (PCS) and Physical Media Attach (PMA) layers of [1]. These modifications are to make the Low Power Entry/Wake-up specification be applicable for 10BASE-T1S. Heading numbering is relative to [1] from this point forward.

22 Reconciliation Sublayer (RS) and Media Independent Interface (MII)

22.1 Functional specifications

22.1.2 MII signal functional specifications

22.1.2.4 TXD (transmit data)

Insert the following paragraph after the third paragraph in 22.2.2.4 as follows:

When low power wake-up signalling capability is supported and enabled, the RS shall use a combination of TX_EN deasserted, TX_ER asserted, and TXD<3:0> equal to 0100 as shown in Table 22-1 to send WUPRQ as defined in 148.4.4.

Modify the fourth paragraph in 22.2.2.4 as follows:

When TX_EN is deasserted and TX_ER is asserted, values of TXD<3:0> other than 0001, 0010, 0011 and 0100 shall have no effect upon the PHY.

Change Table 22-1 as follows (unchanged rows not shown):

Table 22-1--Permissible encodings of TXD<3:0>, TX_EN, and TX_ER

TX_EN	TX_ER	TXD<3:0>	Indication
…			
0	1	0100	WUPRQ request

0	1	~~0100~~0101 through 1111	Reserved
…			

22.1.2.8 RXD (receive data)

Insert the following paragraph into 22.2.2.8 after the fourth paragraph :

When low power wake-up signalling is supported and enabled, the PHY indicates that it is receiving a SUSPEND by asserting the RX_ER signal and driving the value 0100 on RXD<3:0> while RX_DV is de-asserted. See 148.4.7 for the definition and usage of SUSPEND.

Change Table 22-2 as follows (unchanged rows not shown):

Table 22-2--Permissible encoding of RXD<3:0>, RX_ER, and RX_DV

RX_DV	RX_ER	RXD<3:0>	Indication
…			
0	1	0100	SUSPEND indication
0	1	~~0100~~0101 through 1111	Reserved
…			

147 Physical Coding Sublayer (PCS), Physical Medium Attachment (PMA) sublayer and baseband medium, type 10BASE-T1S

147.2 Service primitives and interfaces

Update Figure 147-2—10BASE-T1S PHY interfaces with this one.

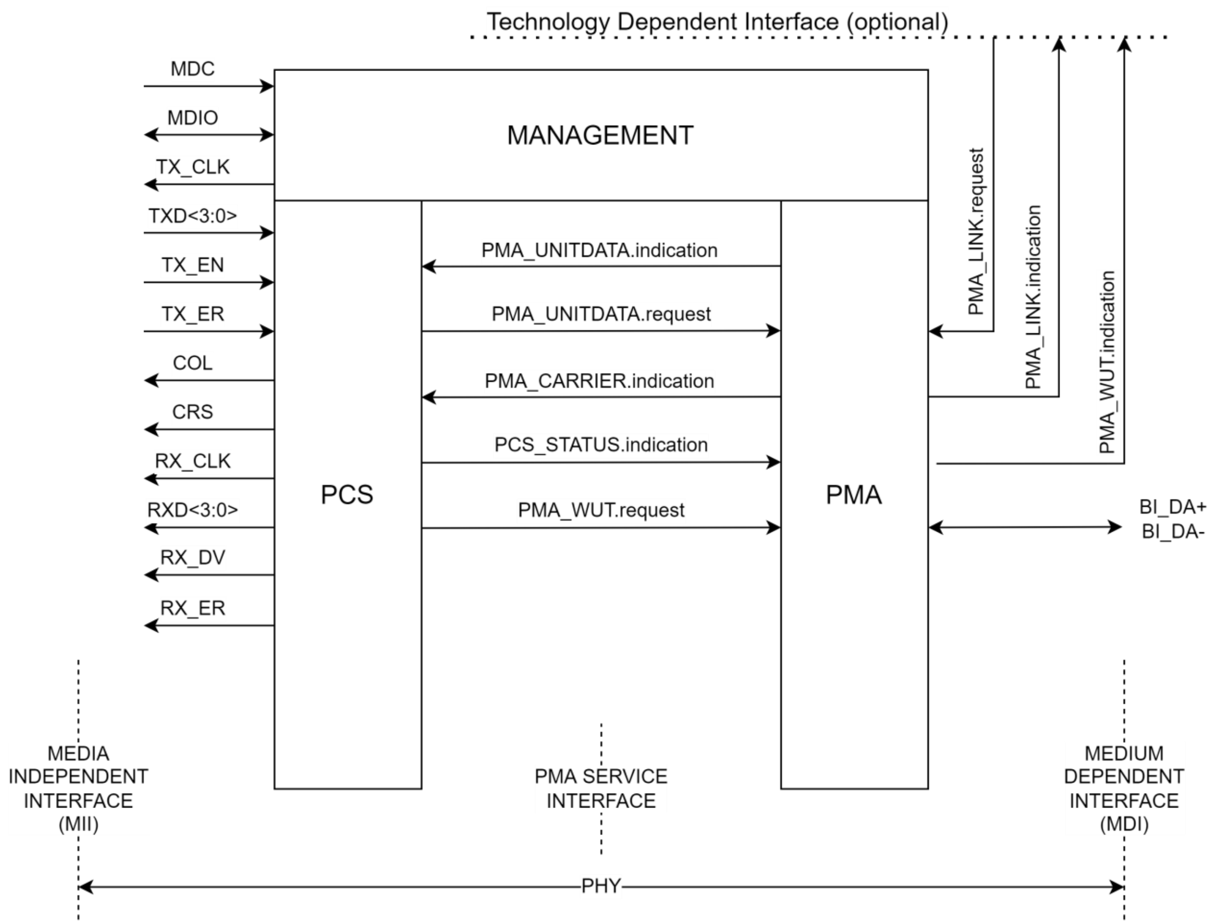


Figure 147-2--10BASE-T1S PHY interfaces

Add below items to list of service primitives

PMA_WUT.request(transmit_wut)

PMA_WUT.indication(status)

Add description of new primitives

147.2.7 PMA_WUT.request

This primitive is generated by the PCS to request the PMA to transmit a WUT.

147.2.7.1 Semantics of the primitive

PMA_WUT.request(transmit_wut)

The transmit_wut parameter can take on one of the following two values

FALSE Transmission of a WUT on the medium is not requested

TRUE Transmission of a WUT on the medium is requested

147.2.7.2 When generated

PCS transmit generates this primitive to indicate a change in transmit_wut.

147.2.7.3 Effect of receipt

The effect of receipt of this primitive is specified in 147.4.2.

147.2.8 PMA_WUT.indication

Reports whether a signal compatible with WUT specified in 8.3.1 is detected on the medium.

147.2.8.1 Semantics of the primitive

PMA_WUT.indication(status)

The status parameter can take on the following two values :

NOT_DETECTED PMA is not receiving a valid WUT from a remote PHY

DETECTED PMA is receiving a valid WUT from a remote PHY

147.2.8.2 When generated

The PMA generates this primitive to indicate a change in status of the WUT presence detection on the medium.

147.2.8.3 Effect of receipt

The effect of receipt of this primitive is specified in 8.4

147.3 Physical Coding Sublayer (PCS) Functions

147.3.1 PCS Reset function

Replace figure 147-3 with this one.

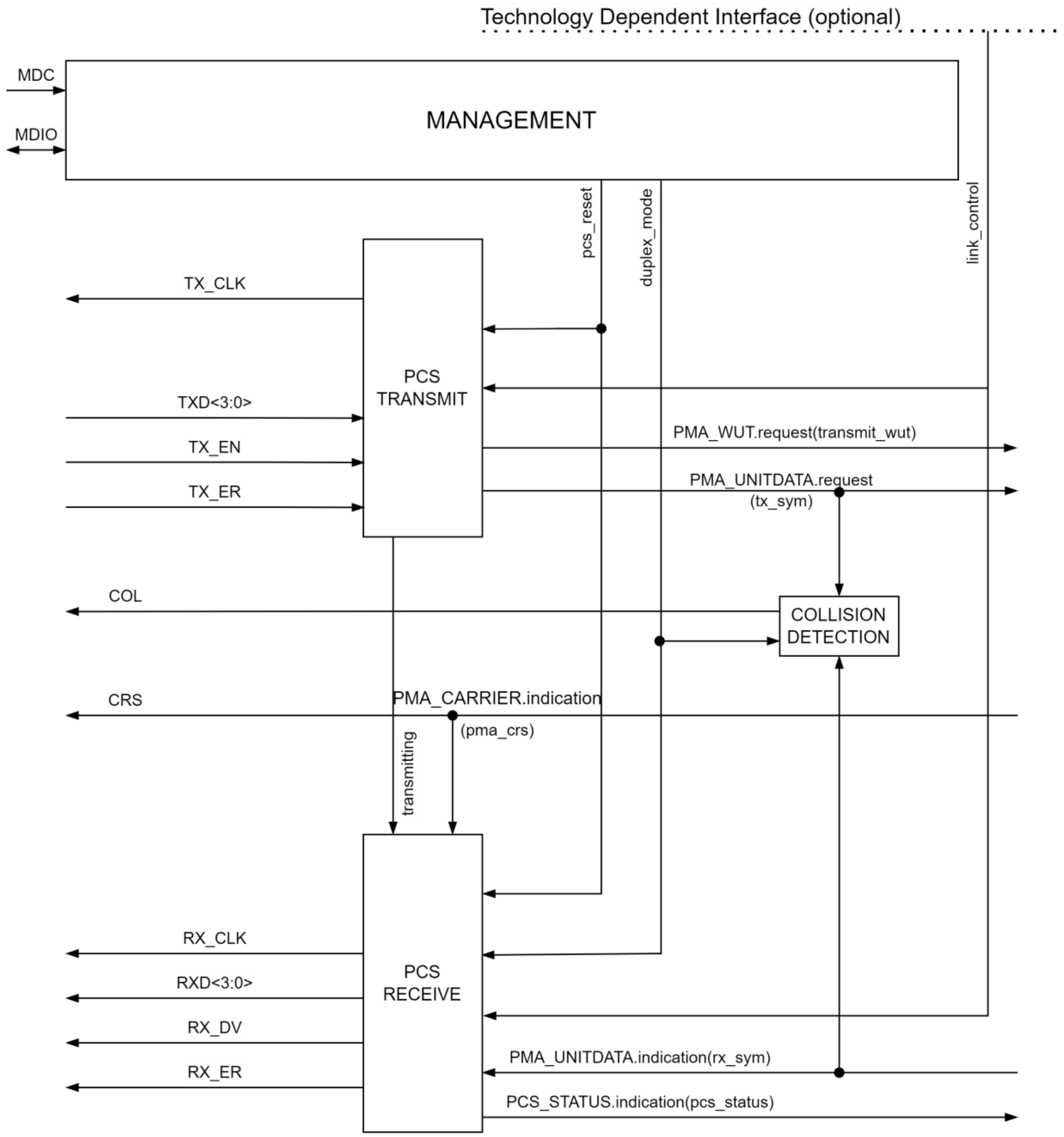


Figure 147-3--PCS reference diagram

147.3.2 PCS Transmit

147.3.2.1 PCS Transmit overview

“Add this text after last paragraph in this section”

When low power functionality is supported and the wut_transmit variable changes, it shall be conveyed to the PMA through PMA_WUT.request primitive.

147.3.2.2 Variables

Replace existing variable descriptions with descriptions below.

link_control

This variable is generated by the Auto-Negotiation function. When Auto-Negotiation is not present or Auto-Negotiation is disabled, link_control has a default value of ENABLE, and may be provided by implementation-dependent functionality. When low power functionality is present this variable may be controlled by the power state function. When set to DISABLE, all PCS functions are switched off and no data can be sent or received.
Values: ENABLE or DISABLE

Add these variables to the end of the variable list

suspend_cnt

This variable is used to count the number of symbols transmitted during SUSPEND

wut_cnt

This variable is used to dimension the duration of WUT transmitted during WUP

wut_transmit

Value of a wake-up tone transmission request to be conveyed to PMA via the PMA_WUT.request primitive.

147.3.2.4 Functions

Update table 147-1—4B/5B Encoding

Table 147-1--4B/5B Encoding

K	N/A	10001	ESDERR
T	N/A	01101	ESD/HB/SUSPEND
R	N/A	00111	ESDOK/ESDBRS

147.3.2.5 State diagram

Replace figure 147-4—PCS Transmit state diagram, part a

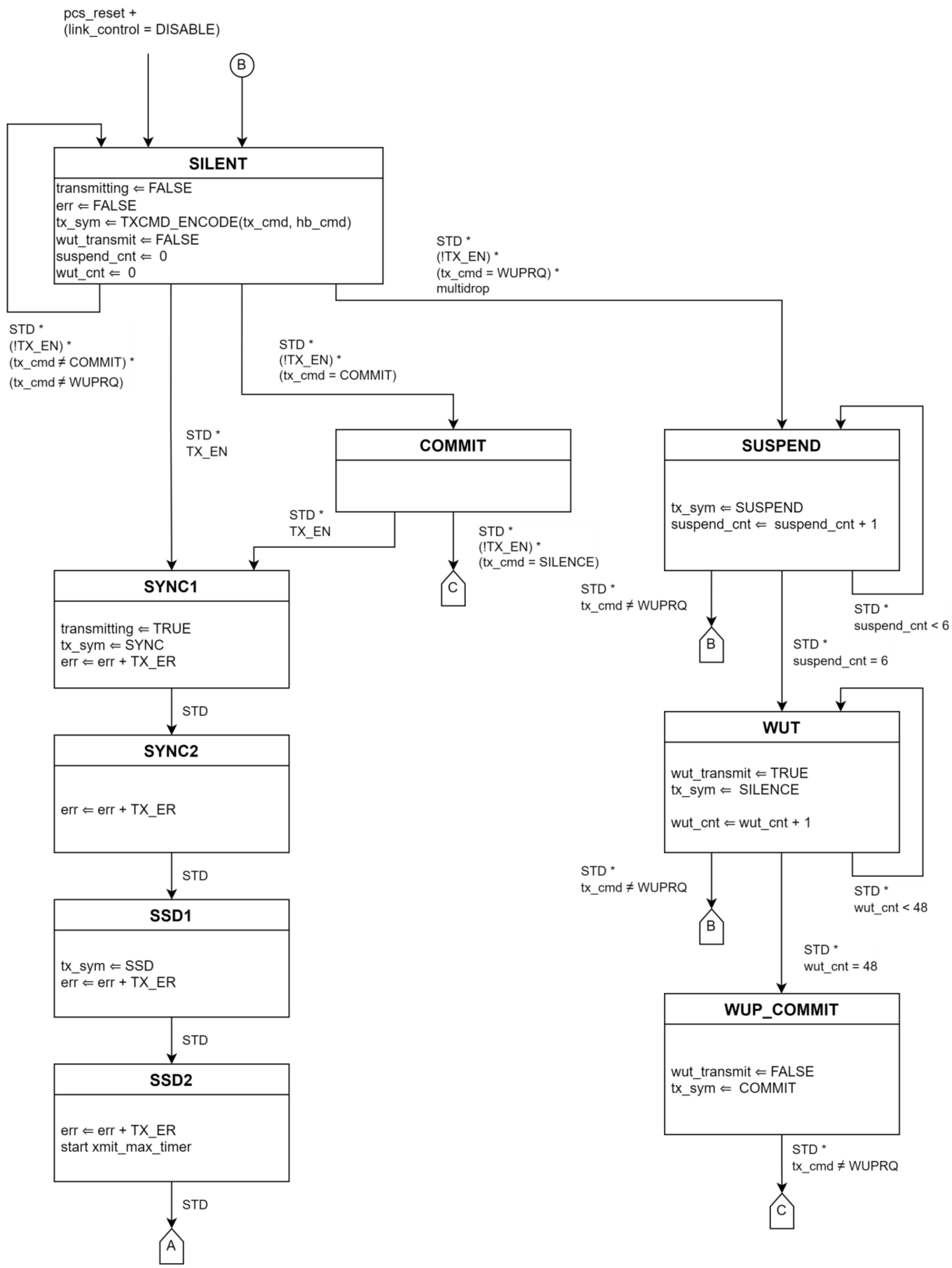


Figure 147-4--PCS Transmit state diagram, part a

147.3.3 PCS Receive

147.3.3.1 PCS Receive Overview

Modify the fifth paragraph of section 22.7.3.1 as follows.

Additionally, the PCS notifies the RS of a received COMMIT or SUSPEND indication by the means of the MII as specified in 22.2.2.8. When a sequence of at least two consecutive SYNC is received, the MII signals RX_DV, RX_ER, and RXD<3:0> are set to the COMMIT indication as shown in Table 22–2. When a sequence of at least two consecutive SUSPEND is received in a multidrop configuration, the MII signals RX_DV, RX_ER, and RXD<3:0> are set to SUSPEND indication as shown in Table 22-2.

147.3.3.7 State diagrams

Add the additional exit path from the WAIT_SYNC state of PCS Receive state diagram, part a (Figure 147-7) as shown.

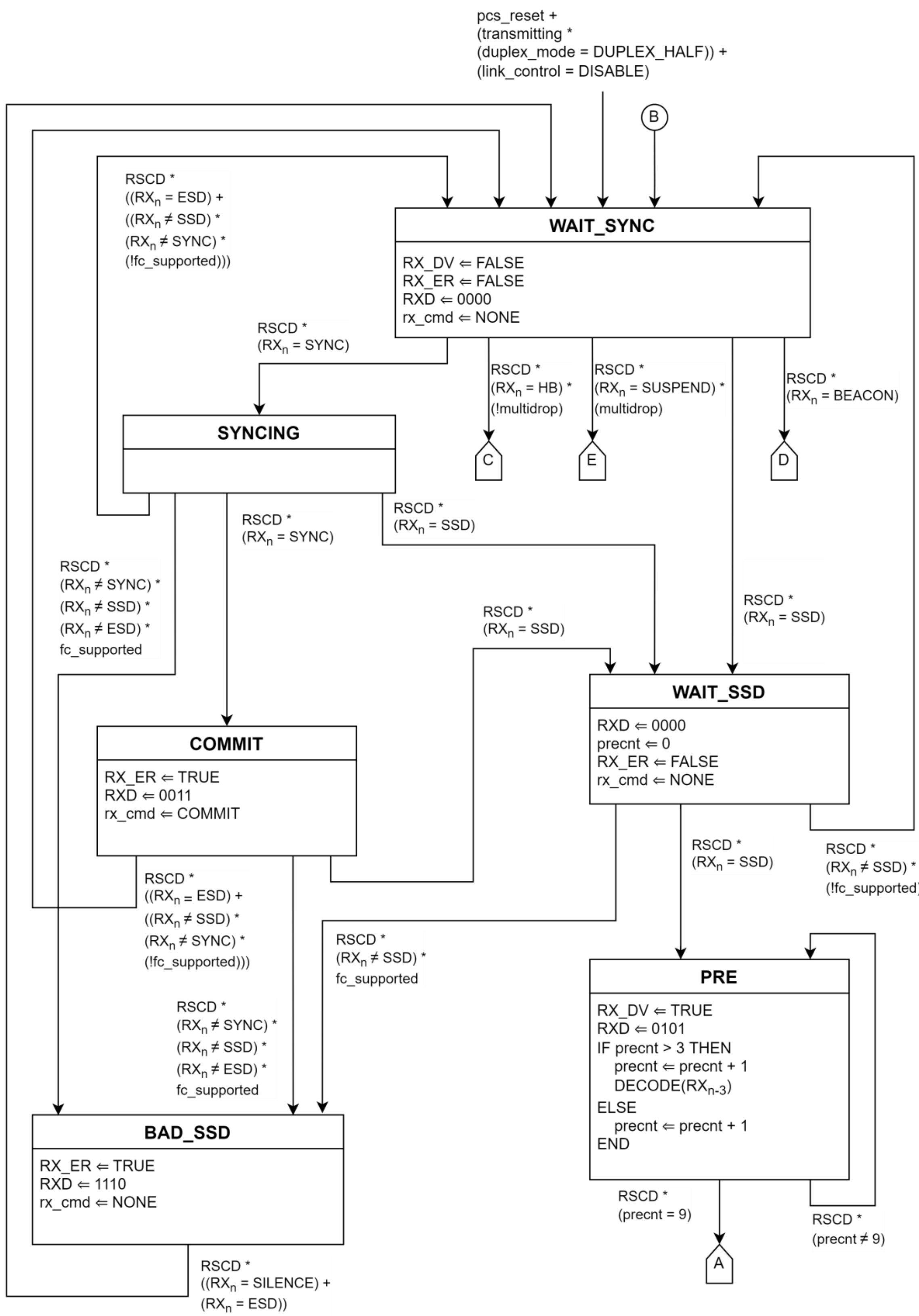


Figure 147-7--PCS Receive state diagram, part a

Add the additional SUSPEND and SUSPEND2 states to PCS Receive state diagram, part b (Figure 147-8) as shown.

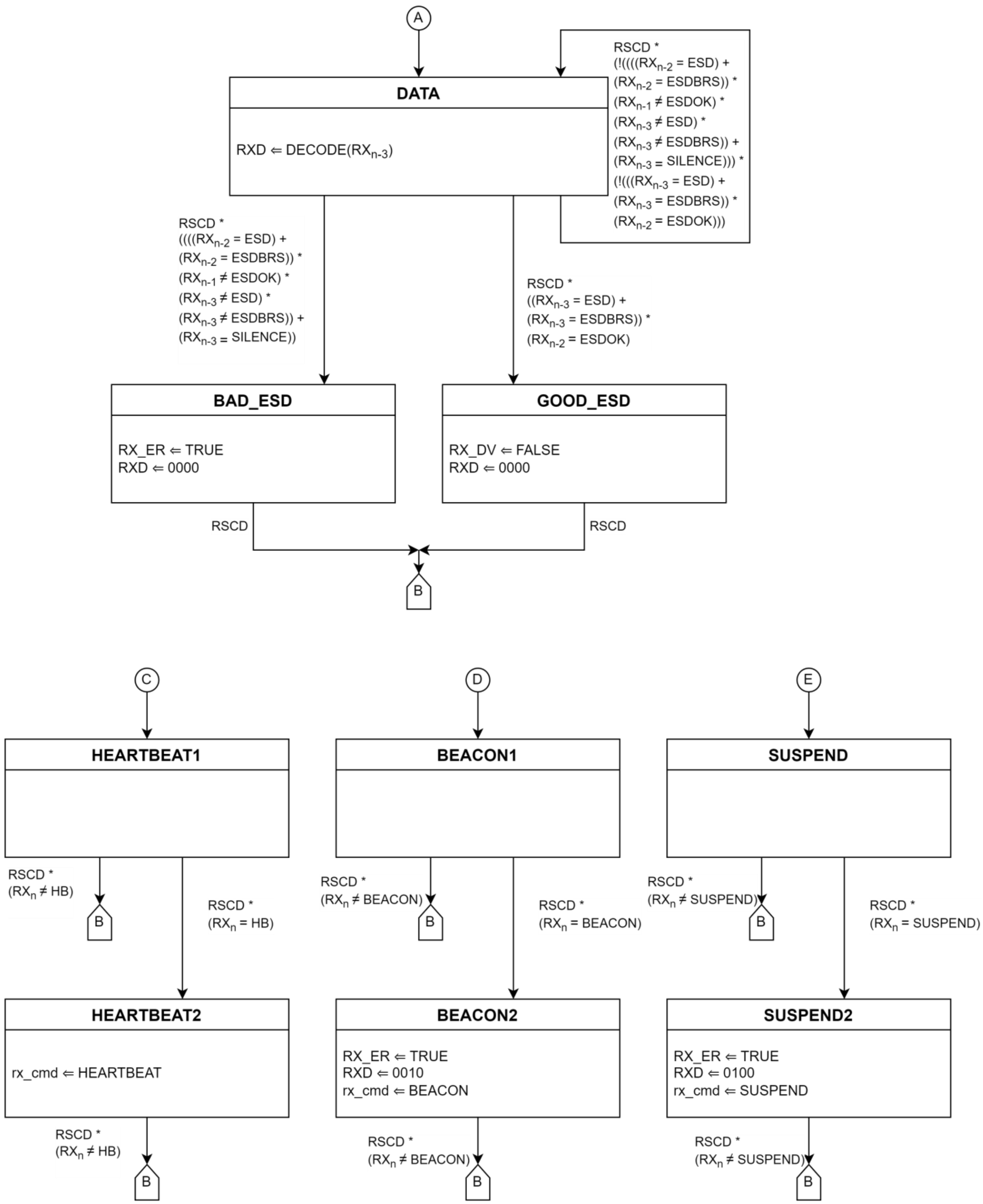


Figure 147-8--PCS Receive state diagram, part b

147.4 Physical Medium Attachment (PMA) sublayer

Replace PMA functional block diagram Figure 147-12 as below:

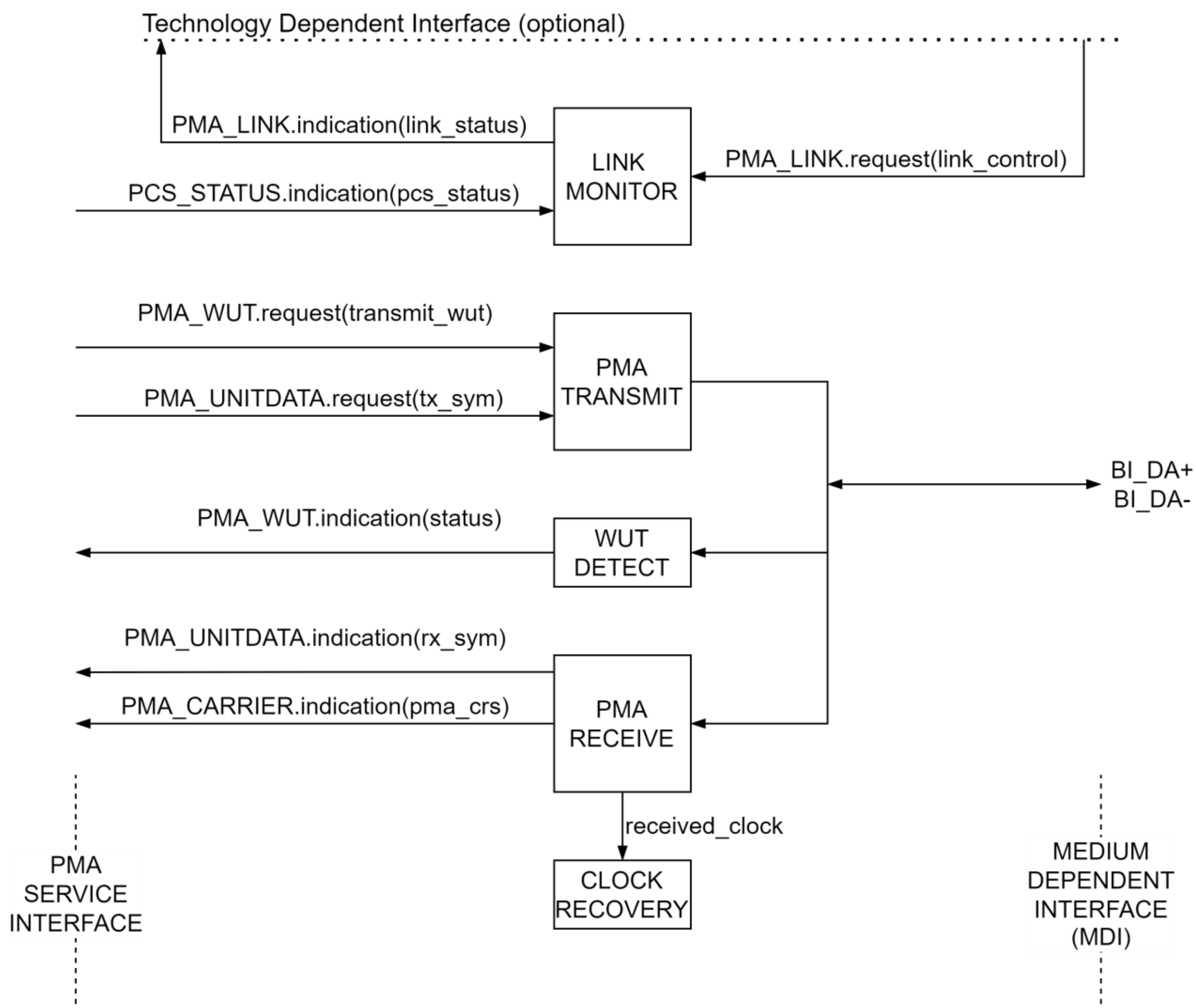


Figure 147-12--PMA functional block diagram

147.4.2 PMA Transmit function

Modify the opening sentence

During transmission, if PMA_WUT.request is inactive (most recent request had transmit_wut parameter set to FALSE), PMA_UNITDATA.request conveys the tx_sym variable to the PMA.

Add the following text to then end of section 147.4.2

If a PMA_WUT.request is active (most recent request had transmit_wut parameter set to TRUE) then it shall transmit a single frequency tone on BI_DA as per the timing outlined below.

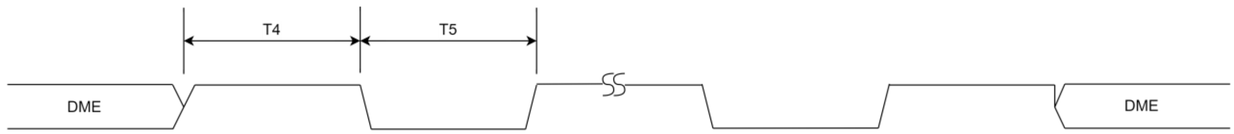


Figure 147-14--WUT encoding

Table 147-2--Table 147-3--WUT timings

Parameter name	Description	Minimum value	Nominal value	Maximum value	Units of measure
T4	Tone high period[12]	-100ppm	800	+100ppm	ns
T5	Tone low period[12]	-100ppm	800	+100ppm	ns

Add the following section after '147.4.4 Link Monitor function'

147.4.5 WUT Detect function

The WUT Detection function comprises a detector for WUT on a single balanced pair of conductors, BI_DA. It notifies the PHY of the detected WUT via the status parameter of the PMA_WUT.indication primitive.

The WUT Detect function shall be executed whenever the presence or absence of a WUT is detected on the MDI.

The WUT Detect function carries out the following tasks:

- PMA_WUT.indication(status) set to DETECTED when WUT is detected.
- PMA_WUT.indication(status) reset to NOT_DETECTED when WUT is not detected.

[12] Should be interpreted as an average period measurement.

148 PLCA Reconciliation Sublayer (RS)

148.4 PLCA Reconciliation Sublayer Operation

148.4.4 PLCA Control

148.4.4.1 PLCA Control state diagram

Insert the following text at the end of this section

If the optional Power Management Client is supported a WUP transmission request will be forwarded to the PCS when the necessary conditions are present.

148.4.4.2 Variables

Update the variables as shown below.

[..]

wur

This variable is set to TRUE by the Wakeup.request service primitive and reset when the wur_timer elapses.

Values: TRUE or FALSE

receiving

Defined as: (RX_DV = TRUE) + (rx_cmd = COMMIT)

Values: TRUE or FALSE

tx_cmd

Command for the PLCA data state diagram to convey to the PHY via the MII.

Values : NONE, WUPRQ, BEACON or COMMIT

rx_cmd

Encoding present on RXD<3:0>, RX_ER, and RX_DV as defined in Table 22–2.

Values:

BEACON: PLCA BEACON indication encoding present on RXD<3:0>, RX_ER, and RX_DV

COMMIT: PLCA COMMIT indication encoding present on RXD<3:0>, RX_ER, and RX_DV

SUSPEND: SUSPEND indication encoding present on RXD<3:0>, RX_ER, and RX_DV

NONE: PLCA BEACON, COMMIT, or SUSPEND indication encoding not present on RXD<3:0>, RX_ER, and RX_DV

[..]

148.4.4.4 Timers

[…]

wur_timer

Defines the duration of the WUP request for the PHY to encode.

Duration: 316 BT +/- 1 BT

148.4.4.6 State Diagram

Update Figure 148-3 and 148-4 with these ones.

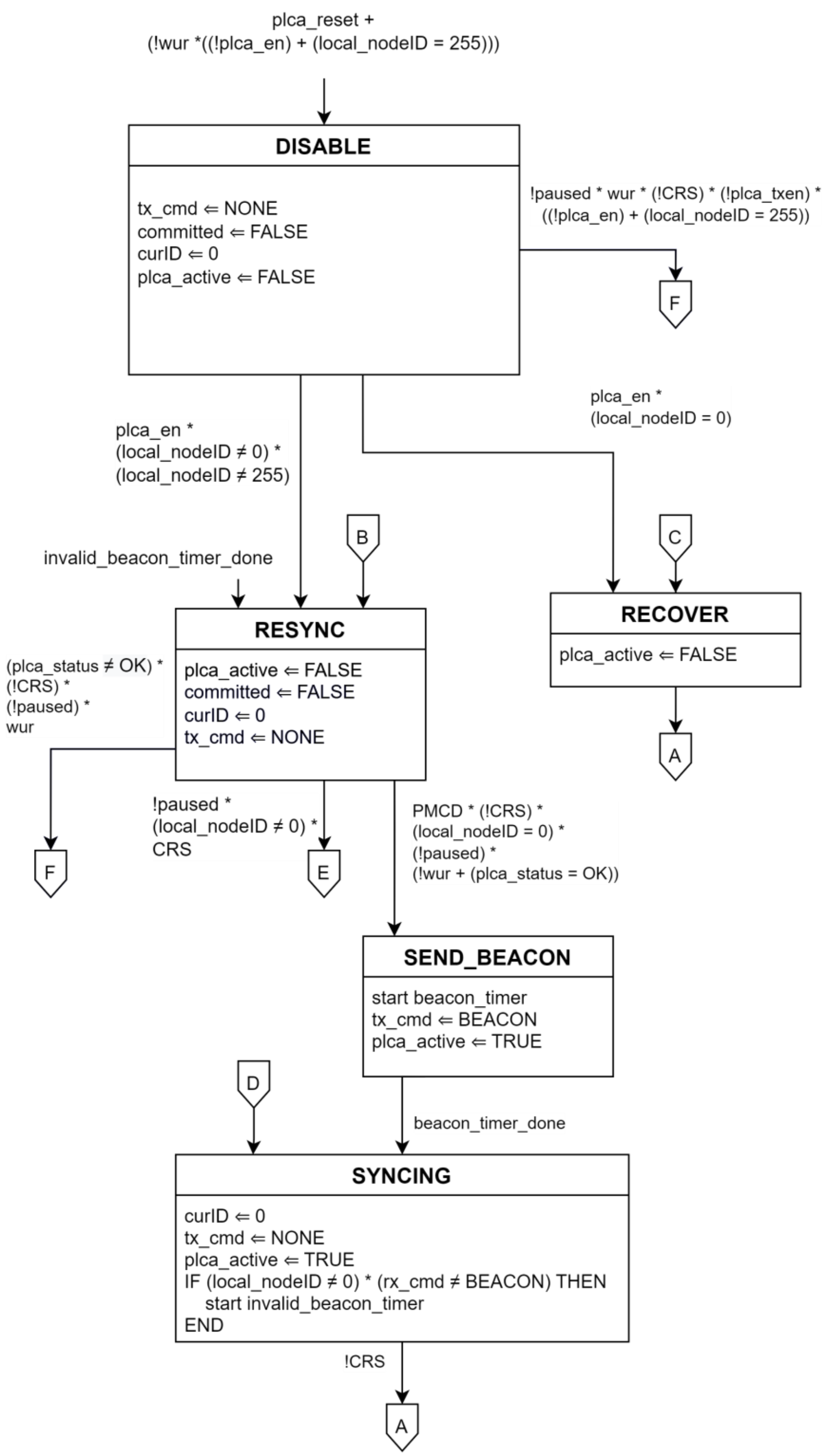


Figure 148-3--PLCA Control state diagram, part a

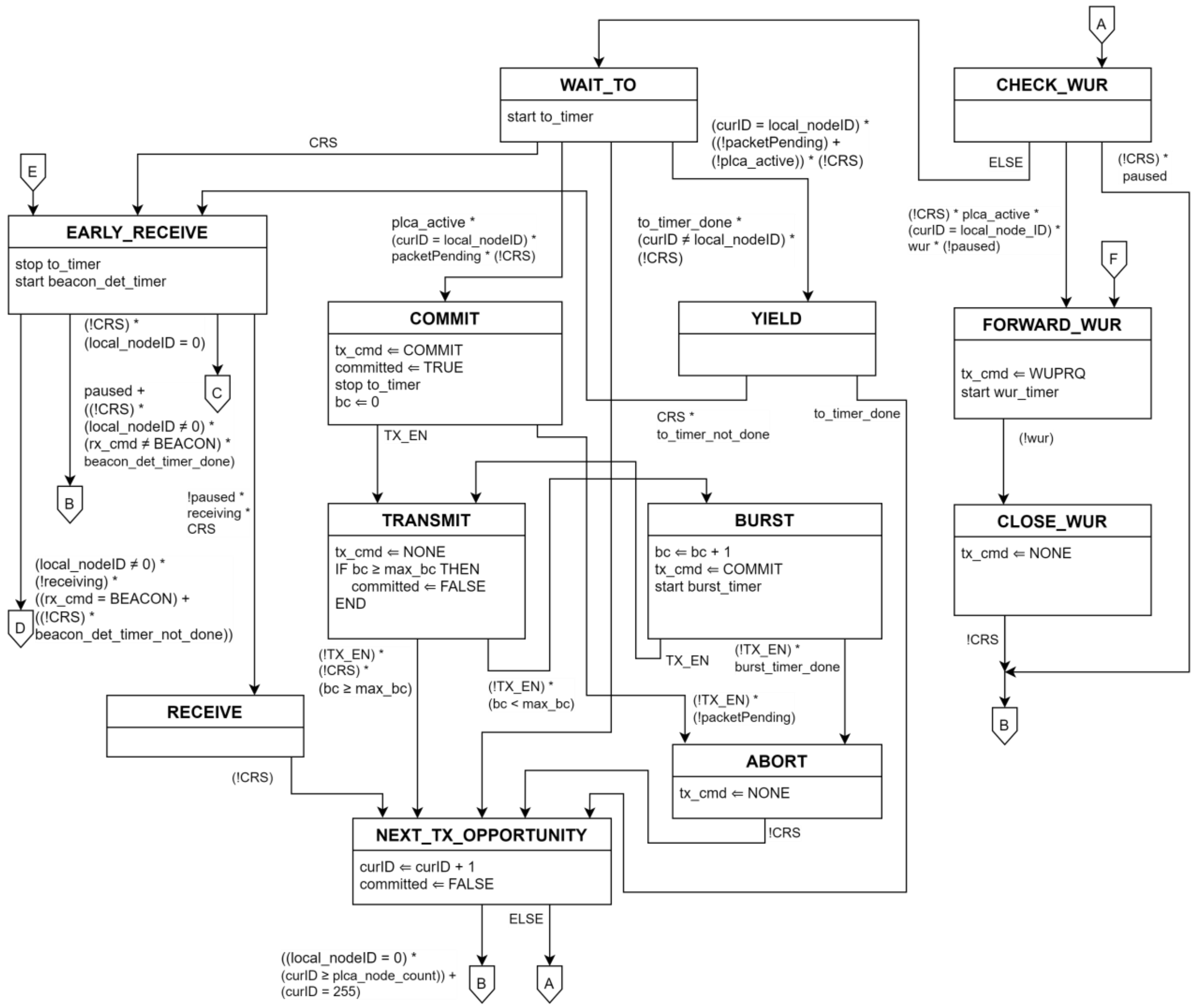


Figure 148-4--PLCA Control state diagram, part b

148.4.5 PLCA Data

148.4.5.7 State Diagram

Update Figure 148-5—PLCA Data state diagram, part a with this one.

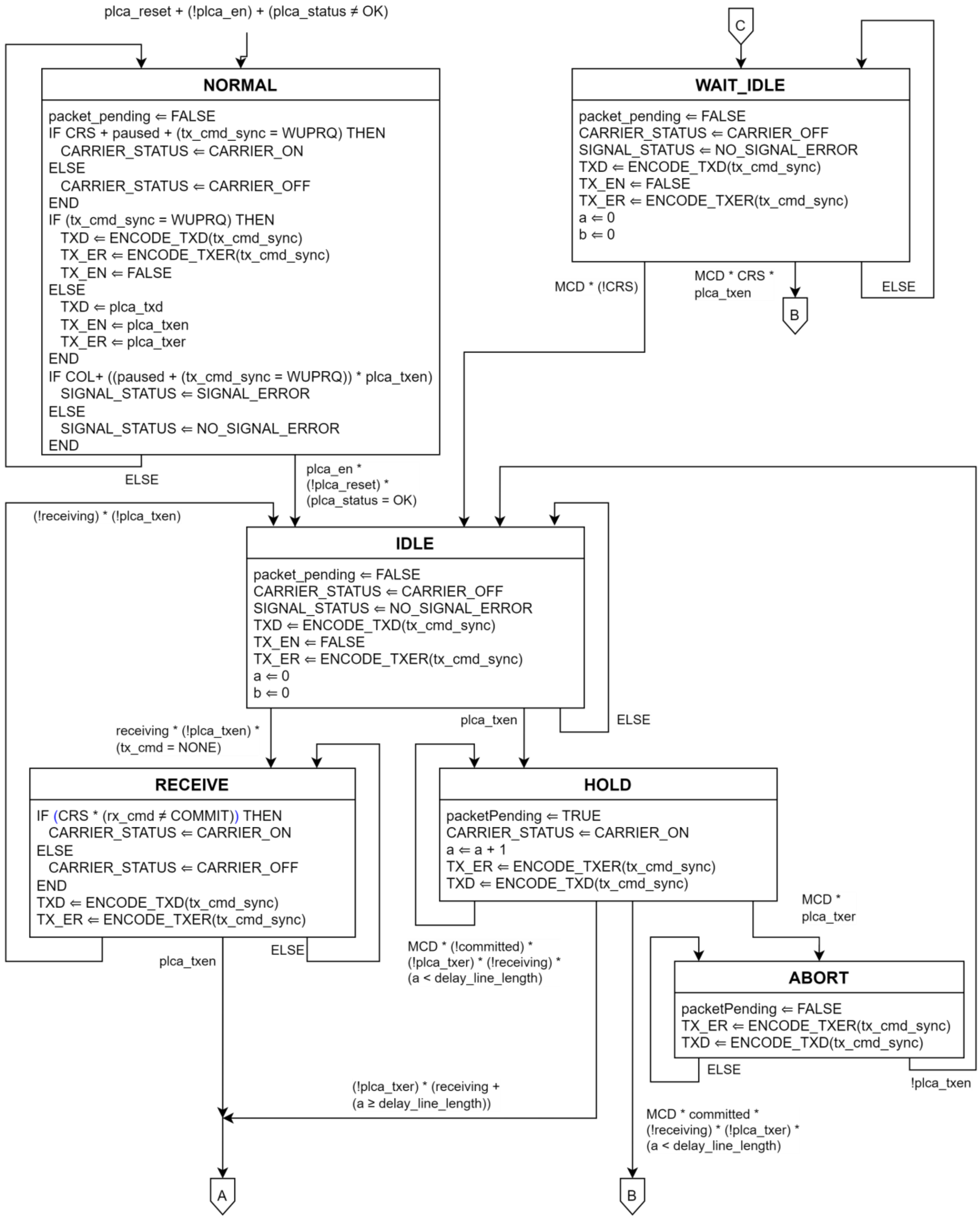


Figure 148-5--PLCA Data state diagram, part a

148.4.7 PLCA Pause

Add this section after 148.4.6 PLCA Status.

148.4.7.1 PLCA Pause state diagram

The PLCA Pause state diagram is responsible for reporting when a recent SUSPEND request has been received. The PLCA Pause function shall conform to the PLCA Pause state diagram in Figure 148- 148-8 and associated state variables and timers.

148.4.7.2 Variables

paused

> Controls the generation of transmit opportunities in the PLCA Control and Data state diagrams. While set to TRUE, the generation of TOs is suspended, and the RS does not convey data to the PHY.
>
> Values : TRUE or FALSE

148.4.7.4 Timers

resume_timer

> Defines the time the pause variable is maintained TRUE after the PHY stops reporting a wake-up indication on the MII.
>
> Duration : 240 BT +/- 5 BT

148.4.7.5 State diagram

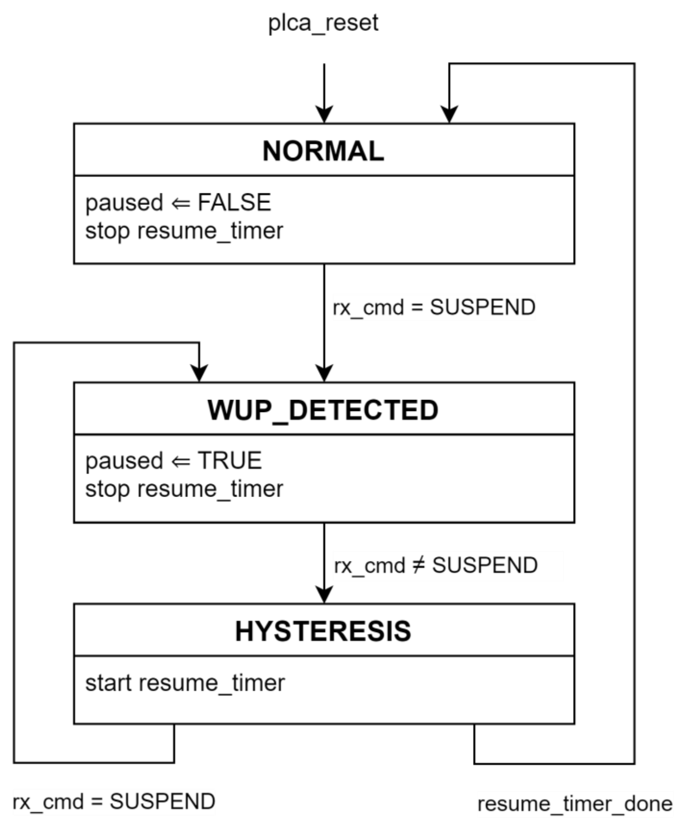


Figure 148-8--PLCA Pause state diagram