

Figure 28-4—Data bit encoding within FLP Bursts

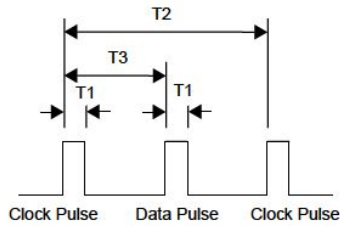


Figure 28-5—FLP Burst pulse-to-pulse timing

The first link pulse in consecutive FLP Bursts shall occur at a 16 ± 8 ms interval (figure 28-6).

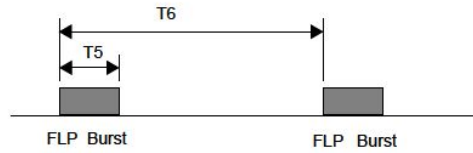


Figure 28-6—FLP Burst to FLP Burst timing

Table 28-1—FLP Burst timing summary

#	Parameter	Min.	Typ.	Max.	Units
T1	Clock/Data Pulse Width (figure 14-12)		100		ns
T2	Clock Pulse to Clock Pulse	111	125	139	μ s
T3	Clock Pulse to Data Pulse (Data = 1)	55.5	62.5	69.5	μ s
T4	Pulses in a Burst	17		33	#
T5	Burst Width		2		ms
T6	FLP Burst to FLP Burst	8	16	24	ms

28.2.1.2 Link Code Word encoding

The base Link Code Word (base page) transmitted within an FLP Burst shall convey the encoding shown in figure 28-7. The Auto-Negotiation function may support additional pages using the Next Page function. Encodings for the Link Code Word(s) used in Next Page exchange are defined in 28.2.3.4. In an FLP Burst, D0 shall be the first bit transmitted.

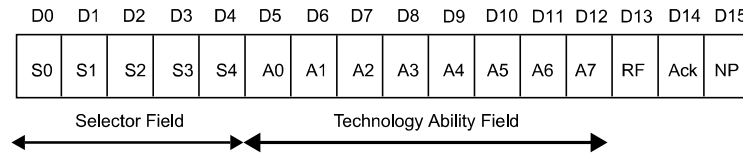


Figure 28-7—Base page encoding

28.2.1.2.1 Selector Field

Selector Field (S[4:0]) is a five bit wide field, encoding 32 possible messages. Selector Field encoding definitions are shown in annex 28A. Combinations not specified are reserved for future use. Reserved combinations of the Selector Field shall not be transmitted.

28.2.1.2.2 Technology Ability Field

Technology Ability Field (A[7:0]) is an eight bit wide field containing information indicating supported technologies specific to the selector field value. These bits are mapped to individual technologies such that abilities are advertised in parallel for a single selector field value. The Technology Ability Field encoding for the IEEE 802.3 selector is described in annex 28B.2. Multiple technologies may be advertised in the Link Code Word. A device shall support the data service ability for a technology it advertises. It is the responsibility of the Arbitration function to determine the common mode of operation shared by a Link Partner and to resolve multiple common modes.

NOTE—While devices using a Selector Field value other than the IEEE 802.3 Selector Field value are free to define the Technology Ability Field bits, it is recommended that the 10BASE-T bit be encoded in the same bit position as in the IEEE 802.3 selector. A common bit position can be important if the technology using the other selector will ever coexist on a device that also offers a 10BASE-T mode.

28.2.1.2.3 Remote Fault

Remote Fault (RF) is encoded in bit D13 of the base Link Code Word. The default value is logic zero. The Remote Fault bit provides a standard transport mechanism for the transmission of simple fault information. When the RF bit in the Auto-Negotiation advertisement register (register 4) is set to logic one, the RF bit in the transmitted base Link Code Word is set to logic one. When the RF bit in the received base Link Code Word is set to logic one, the Remote Fault bit in the MII status register (register 1) will be set to logic one, if the MII management function is present.

The Remote Fault bit shall be used in accordance with the Remote Fault function specifications (28.2.3.5).

28.2.1.2.4 Acknowledge

Acknowledge (Ack) is used by the Auto-Negotiation function to indicate that a device has successfully received its Link Partner's Link Code Word. The Acknowledge Bit is encoded in bit D14 regardless of the value of the Selector Field or Link Code Word encoding. If no Next Page information is to be sent, this bit

shall be set to logic one in the Link Code Word after the reception of at least three consecutive and consistent FLP Bursts (ignoring the Acknowledge bit value). If Next Page information is to be sent, this bit shall be set to logic one after the device has successfully received at least three consecutive and matching FLP Bursts (ignoring the Acknowledge bit value), and will remain set until the Next Page information has been loaded into the Auto-Negotiation Next Page register (register 7). In order to save the current received Link Code Word, this must be read from the Auto-Negotiation link partner ability register (register 6) before the Next Page of transmit information is loaded into the Auto-Negotiation Next Page register. After the COMPLETE ACKNOWLEDGE state has been entered, the Link Code Word shall be transmitted six to eight (inclusive) times.

28.2.1.2.5 Next Page

Next Page (NP) is encoded in bit D15 regardless of the Selector Field value or Link Code Word encoding. Support for transmission and reception of additional Link Code Word encodings is optional. If Next Page ability is not supported, the NP bit shall always be set to logic zero. If a device implements Next Page ability and wishes to engage in Next Page exchange, it shall set the NP bit to logic one. A device may implement Next Page ability and choose not to engage in Next Page exchange by setting the NP bit to a logic zero. The Next Page function is defined in 28.2.3.4.

28.2.1.3 Transmit Switch function

The Transmit Switch function shall enable the transmit path from a single technology-dependent PMA to the MDI once a highest common denominator choice has been made and Auto-Negotiation has completed.

During Auto-Negotiation, the Transmit Switch function shall connect only the FLP Burst generator controlled by the Transmit State Diagram, figure 28-14, to the MDI.

When a PMA is connected to the MDI through the Transmit Switch function, the signals at the MDI shall conform to all of the PHY's specifications.

28.2.2 Receive function requirements

The Receive function detects the NLP sequence using the NLP Receive Link Integrity Test function of figure 28-17. The NLP Receive Link Integrity Test function will not detect link pass based on carrier sense.

The Receive function detects the FLP Burst sequence, decodes the information contained within, and stores the data in rx_link_code_word[16:1]. The Receive function incorporates a receive switch to control connection to the 100BASE-TX or 100BASE-T4 PMAs in addition to the NLP Receive Link Integrity Test function, excluding the 10BASE-T Link Integrity Test function present in a 10BASE-T PMA. If Auto-Negotiation detects link_status=READY from any of the technology-dependent PMAs prior to FLP Burst detection, the autoneg_wait_timer (28.3.2) is started. If any other technology-dependent PMA indicates link_status=READY when the autoneg_wait_timer expires, Auto-Negotiation will not allow any data service to be enabled and may signal this as a remote fault to the Link Partner using the base page and will flag this in the Local Device by setting the Parallel Detection Fault bit (6.4) in the Auto-Negotiation expansion register. If a 10BASE-T PMA exists above the Auto-Negotiation function, it is not permitted to receive MDI activity in parallel with the NLP Receive Link Integrity Test function or any other technology-dependent function.

28.2.2.1 FLP Burst ability detection and decoding

In figures 28-8 to 28-10, the symbol "t₀=0" indicates the event that caused the timers described to start, and all subsequent times given are referenced from that point. All timers referenced shall expire within the range specified in table 28-8 in 28.3.2.

The Receive function shall identify the Link Partner as Auto-Negotiation able if it receives 6 to 17 (inclusive) consecutive link pulses that are separated by at least `flp_test_min_timer` time (5–25 μ s) but less than `flp_test_max_timer` time (165–185 μ s) as shown in figure 28-8. The information contained in the FLP Burst that identifies the Link Partner as Auto-Negotiation able shall not be passed to the Arbitration function if the FLP Burst is not complete. The Receive function may use the FLP Burst that identifies the Link Partner as Auto-Negotiation able for ability matching if the FLP Burst is complete. However, it is not required to use this FLP Burst for any purpose other than identification of the Link Partner as Auto-Negotiation able. Implementations may ignore multiple FLP Bursts before identifying the Link Partner as Auto-Negotiation able to allow for potential receive equalization time.

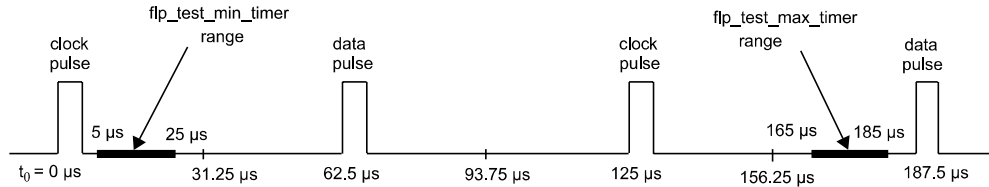


Figure 28-8—FLP detect timers (`flp_test_min/max_timers`)

The Receive function captures and decodes link pulses received in FLP Bursts. The first link pulse in an FLP Burst shall be interpreted as a clock link pulse. Detection of a clock link pulse shall restart the `data_detect_min_timer` and `data_detect_max_timer`. The `data_detect_min/max_timers` enable the receiver to distinguish data pulses from clock pulses and logic one data from logic zero data, as follows:

- a) If, during an FLP Burst, a link pulse is received when the `data_detect_min_timer` has expired while the `data_detect_max_timer` has not expired, the data bit shall be interpreted as a logic one (figure 28-9).
- b) If, during an FLP Burst, a link pulse is received after the `data_detect_max_timer` has expired, the data bit shall be interpreted as a logic zero (figure 28-9) and that link pulse shall be interpreted as a clock link pulse.

As each data bit is identified it is stored in the appropriate `rx_link_code_word[16:1]` element.

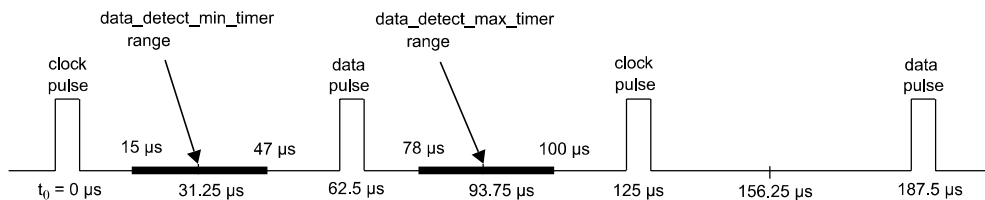
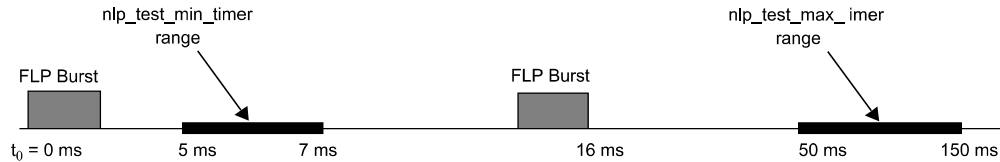


Figure 28-9—FLP data detect timers (`data_detect_min/max_timers`)

FLP Bursts conforming to the `nlp_test_min_timer` and `nlp_test_max_timer` timing as shown in figure 28-10 shall be considered to have valid separation.

28.2.2.2 NLP detection

NLP detection is accomplished via the NLP Receive Link Integrity Test function in figure 28-17. The NLP Receive Link Integrity Test function is a modification of the original 10BASE-T Link Integrity Test function (figure 14-6), where the detection of receive activity will not cause a transition to the LINK TEST PASS state during Auto-Negotiation. The NLP Receive Link Integrity Test function also incorporates the Technology-Dependent Interface requirements.



NOTE—The reference for the starting of the nlp_test_min_timer is from the beginning of the FLP Burst, as shown by t_0 , while the reference for the starting of the nlp_test_max_timer is from the expiration of the nlp_test_min_timer.

Figure 28-10—FLP Burst timer (nlp_test_min/max_timers)

28.2.2.3 Receive Switch function

The Receive Switch function shall enable the receive path from the MDI to a single technology-dependent PMA once a highest common denominator choice has been made and Auto-Negotiation has completed.

During Auto-Negotiation, the Receive Switch function shall connect both the FLP Burst receiver controlled by the Receive state diagram, figure 28-15, and the NLP Receive Link Integrity Test state diagram, figure 28-17, to the MDI. During Auto-Negotiation, the Receive Switch function shall also connect the 100BASE-TX and 100BASE-T4 PMA receivers to the MDI if the 100BASE-TX and/or 100BASE-T4 PMAs are present.

When a PMA is connected to the MDI through the Receive Switch function, the signals at the PMA shall conform to all of the PHY's specifications.

28.2.2.4 Link Code Word matching

The Receive function shall generate ability_match, acknowledge_match, and consistency_match variables as defined in 28.3.1.

28.2.3 Arbitration function requirements

The Arbitration function ensures proper sequencing of the Auto-Negotiation function using the Transmit function and Receive function. The Arbitration function enables the Transmit function to advertise and acknowledge abilities. Upon indication of acknowledgment, the Arbitration function determines the highest common denominator using the priority resolution function and enables the appropriate technology-dependent PMA via the Technology-Dependent Interface (28.2.6).

28.2.3.1 Parallel detection function

The Local Device detects a Link Partner that supports Auto-Negotiation by FLP Burst detection. The Parallel Detection function allows detection of Link Partners that support 100BASE-TX, 100BASE-T4, and/or 10BASE-T, but do not support Auto-Negotiation. Prior to detection of FLP Bursts, the Receive Switch shall direct MDI receive activity to the NLP Receive Link Integrity Test state diagram, 100BASE-TX and 100BASE-T4 PMAs, if present, but shall not direct MDI receive activity to the 10BASE-T or any other PMA. If at least one of the 100BASE-TX, 100BASE-T4, or NLP Receive Link Integrity Test functions establishes link_status=READY, the LINK STATUS CHECK state is entered and the autoneg_wait_timer is started. If exactly one link_status=READY indication is present when the autoneg_wait_timer expires, then Auto-Negotiation shall set link_control=ENABLE for the PMA indicating link_status=READY. If a PMA is enabled, the Arbitration function shall set link_control=DISABLE to all other PMAs and indicate that Auto-Negotiation has completed. On transition to the FLP LINK GOOD CHECK state from the LINK STA-

TUS CHECK state the Parallel Detection function shall set the bit in the link partner ability register (register 5) corresponding to the technology detected by the Parallel Detection function.

NOTES

1—Native 10BASE-T devices will be detected by the NLP Receive Link Integrity Test function, an integrated part of the Auto-Negotiation function. Hence, Parallel Detection for the 10BASE-T PMA is not required or allowed.

2—When selecting the highest common denominator through the Parallel Detection function, only the half-duplex mode corresponding to the selected PMA may automatically be detected.

28.2.3.2 Renegotiation function

A renegotiation request from any entity, such as a management agent, shall cause the Arbitration function to disable all technology-dependent PMAs and halt any transmit data and link pulse activity until the `break_link_timer` expires (28.3.2). Consequently, the Link Partner will go into link fail and normal Auto-Negotiation resumes. The Local Device shall resume Auto-Negotiation after the `break_link_timer` has expired by issuing FLP Bursts with the base page valid in `tx_link_code_word[16:1]`.

Once Auto-Negotiation has completed, renegotiation will take place if the Highest Common Denominator technology that receives `link_control=ENABLE` returns `link_status=FAIL`. To allow the PMA an opportunity to determine link integrity using its own link integrity test function, the `link_fail_inhibit_timer` qualifies the `link_status=FAIL` indication such that renegotiation takes place if the `link_fail_inhibit_timer` has expired and the PMA still indicates `link_status=FAIL` or `link_status=READY`.

28.2.3.3 Priority Resolution function

Since a Local Device and a Link Partner may have multiple common abilities, a mechanism to resolve which mode to configure is required. The mechanism used by Auto-Negotiation is a Priority Resolution function that predefines the hierarchy of supported technologies. The single PMA enabled to connect to the MDI by Auto-Negotiation shall be the technology corresponding to the bit in the Technology Ability Field common to the Local Device and Link Partner that has the highest priority as defined in annex 28B. This technology is referred to as the Highest Common Denominator, or HCD, technology. If the Local Device receives a Technology Ability Field with a bit set that is reserved, the Local Device shall ignore that bit for priority resolution. Determination of the HCD technology occurs on entrance to the FLP LINK GOOD CHECK state. In the event that a technology is chosen through the Parallel Detection function, that technology shall be considered the highest common denominator (HCD) technology. In the event that there is no common technology, HCD shall have a value of "NULL," indicating that no PMA receives `link_control=ENABLE`, and `link_status_[HCD]=FAIL`.

28.2.3.4 Next Page function

The Next Page function uses the standard Auto-Negotiation arbitration mechanisms to allow exchange of arbitrary pieces of data. Data is carried by optional Next Pages of information, which follow the transmission and acknowledgment procedures used for the base Link Code Word. Two types of Next Page encodings are defined: Message Pages and Unformatted Pages.

A dual acknowledgment system is used. Acknowledge (Ack) is used to acknowledge receipt of the information; Acknowledge 2 (Ack2) is used to indicate that the receiver is able to act on the information (or perform the task) defined in the message.

Next Page operation is controlled by the same two mandatory control bits, Next Page and Acknowledge, used in the Base Link Code Word. Setting the NP bit in the Base Link Code Word to logic one indicates that the device is Next Page Able. If both a device and its Link Partner are Next Page Able, then Next Page exchange may occur. If one or both devices are not Next Page Able, then Next Page exchange will not occur and, after the base Link Code Words have been exchanged, the FLP LINK GOOD CHECK state will be

entered. The Toggle bit is used to ensure proper synchronization between the Local Device and the Link Partner.

Next Page exchange occurs after the base Link Code Words have been exchanged. Next Page exchange consists of using the normal Auto-Negotiation arbitration process to send Next Page messages. Two message encodings are defined: Message Pages, which contain predefined 11 bit codes, and Unformatted Pages. Unformatted Pages can be combined to send extended messages. If the Selector Field values do not match, then each series of Unformatted Pages shall be preceded by a Message Page containing a message code that defines how the following Unformatted Pages will be interpreted. If the Selector Field values match, then the convention governing the use of Message Pages shall be as defined by the Selector Field value definition. Any number of Next Pages may be sent in any order; however, it is recommended that the total number of Next Pages sent be kept small to minimize the link startup time.

Next Page transmission ends when both ends of a link segment set their Next Page bits to logic zero, indicating that neither has anything additional to transmit. It is possible for one device to have more pages to transmit than the other device. Once a device has completed transmission of its Next Page information, it shall transmit Message Pages with Null message codes and the NP bit set to logic zero while its Link Partner continues to transmit valid Next Pages. An Auto-Negotiation able device shall recognize reception of Message Pages with Null message codes as the end of its Link Partner's Next Page information.

28.2.3.4.1 Next Page encodings

The Next Page shall use the encoding shown in figures 28-11 and 28-12 for the NP, Ack, MP, Ack2, and T bits. The 11-bit field D10–D0 shall be encoded as a Message Code Field if the MP bit is logic one and an Unformatted Code Field if MP is set to logic zero.

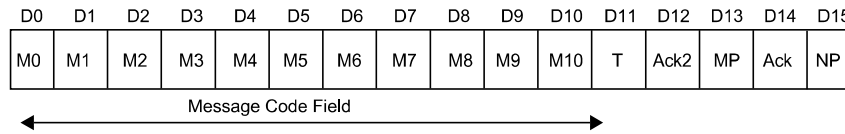


Figure 28-11—Message Page encoding

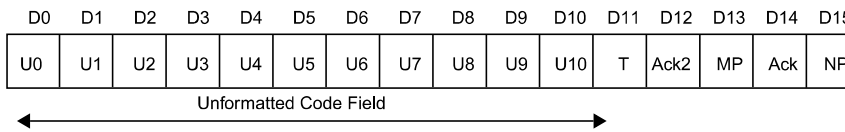


Figure 28-12—Unformatted Page encoding

28.2.3.4.2 Next Page

Next Page (NP) is used by the Next Page function to indicate whether or not this is the last Next Page to be transmitted. NP shall be set as follows:

- logic zero = last page.
- logic one = additional Next Page(s) will follow.

28.2.3.4.3 Acknowledge

As defined in 28.2.1.2.4.

28.2.3.4.4 Message Page

Message Page (MP) is used by the Next Page function to differentiate a Message Page from an Unformatted Page. MP shall be set as follows:

logic zero = Unformatted Page.
logic one = Message Page.

28.2.3.4.5 Acknowledge 2

Acknowledge 2 (Ack2) is used by the Next Page function to indicate that a device has the ability to comply with the message. Ack2 shall be set as follows:

logic zero = cannot comply with message.
logic one = will comply with message.

28.2.3.4.6 Toggle

Toggle (T) is used by the Arbitration function to ensure synchronization with the Link Partner during Next Page exchange. This bit shall always take the opposite value of the Toggle bit in the previously exchanged Link Code Word. The initial value of the Toggle bit in the first Next Page transmitted is the inverse of bit 11 in the base Link Code Word and, therefore, may assume a value of logic one or zero. The Toggle bit shall be set as follows:

logic zero = previous value of the transmitted Link Code Word equalled logic one.
logic one = previous value of the transmitted Link Code Word equalled logic zero.

28.2.3.4.7 Message Page encoding

Message Pages are formatted pages that carry a single predefined Message Code, which is enumerated in annex 28C. Two-thousand and forty-eight Message Codes are available. The allocation of these codes will be controlled by the contents of annex 28C. If the Message Page bit is set to logic one, then the bit encoding of the Link Code Word shall be interpreted as a Message Page.

28.2.3.4.8 Message Code Field

Message Code Field (M[10:0]) is an eleven bit wide field, encoding 2048 possible messages. Message Code Field definitions are shown in annex 28C. Combinations not specified are reserved for future use. Reserved combinations of the Message Code Field shall not be transmitted.

28.2.3.4.9 Unformatted Page encoding

Unformatted Pages carry the messages indicated by Message Pages. Five control bits are predefined, the remaining 11 bits may take on an arbitrary value. If the Message Page bit is set to logic zero, then the bit encoding of the Link Code Word shall be interpreted as an Unformatted Page.

28.2.3.4.10 Unformatted Code Field

Unformatted Code Field (U[10:0]) is an eleven bit wide field, which may contain an arbitrary value.

28.2.3.4.11 Use of Next Pages

- a) Both devices must indicate Next Page ability for either to commence exchange of Next Pages.
- b) If both devices are Next Page able, then both devices shall send at least one Next Page.
- c) Next Page exchange shall continue until neither device on a link has more pages to transmit as indicated by the NP bit. A Message Page with a Null Message Code Field value shall be sent if the device has no other information to transmit.
- d) A Message Code can carry either a specific message or information that defines how following Unformatted Page(s) should be interpreted.
- e) If a Message Code references Unformatted Pages, the Unformatted Pages shall immediately follow the referencing Message Code in the order specified by the Message Code.
- f) Unformatted Page users are responsible for controlling the format and sequencing for their Unformatted Pages.

28.2.3.4.12 MII register requirements

The Next Page Transmit register defined in 28.2.4.1.6 shall hold the Next Page to be sent by Auto-Negotiation. Received Next Pages may be stored in the Auto-Negotiation link partner ability register.

28.2.3.5 Remote fault sensing function

The Remote Fault function may indicate to the Link Partner that a fault condition has occurred using the Remote Fault bit and, optionally, the Next Page function.

Sensing of faults in a device as well as subsequent association of faults with the Remote Fault bit shall be optional. If the Local Device has no mechanism to detect a fault or associate a fault condition with the received Remote Fault bit indication, then it shall transmit the Remote Fault bit with the value contained in the Auto-Negotiation advertisement register bit (4.13).

A Local Device may indicate it has sensed a fault to its Link Partner by setting the Remote Fault bit in the Auto-Negotiation advertisement register and renegotiating.

If the Local Device sets the Remote Fault bit to logic one, it may also use the Next Page function to specify information about the fault that has occurred. Remote Fault Message Page Codes have been specified for this purpose.

The Remote Fault bit shall remain set until after successful negotiation with the base Link Code Word, at which time the Remote Fault bit shall be reset to a logic zero. On receipt of a base Link Code Word with the Remote Fault bit set to logic one, the device shall set the Remote Fault bit in the MII status register (1.4) to logic one if the MII management function is present.

28.2.4 Management function requirements

The management interface is used to communicate Auto-Negotiation information to the management entity. If an MII is physically implemented, then management access is via the MII Management interface. Where no physical embodiment of the MII exists, an equivalent to MII registers 0, 1, 4, 5, 6, and 7 (clause 22) are recommended to be provided.

28.2.4.1 Media Independent Interface

The Auto-Negotiation function shall have five dedicated registers:

- a) MII control register (register 0).
- b) MII status register (register 1).

- c) Auto-Negotiation advertisement register (register 4).
- d) Auto-Negotiation link partner ability register (register 5).
- e) Auto-Negotiation expansion register (register 6).

If the Next Page function is implemented, the Auto-Negotiation Next Page Transmit Register (register 7) shall be implemented.

28.2.4.1.1 MII control register

MII control register (register 0) provides the mechanism to disable/enable and/or restart Auto-Negotiation. The definition for this register is provided in 22.2.4.1.

The Auto-Negotiation function shall be enabled by setting bit 0.12 to a logic one. If bit 0.12 is set to a logic one, then bits 0.13 and 0.8 shall have no effect on the link configuration, and the Auto-Negotiation process will determine the link configuration. If bit 0.12 is cleared to logic zero, then bits 0.13 and 0.8 will determine the link configuration regardless of the prior state of the link configuration and the Auto-Negotiation process.

A PHY shall return a value of one in bit 0.9 until the Auto-Negotiation process has been initiated. The Auto-Negotiation process shall be initiated by setting bit 0.9 to a logic one. If Auto-Negotiation was completed prior to this bit being set, the process shall be reinitiated. If a PHY reports via bit 1.3 that it lacks the ability to perform Auto-Negotiation, then this bit will have no meaning, and should be written as zero. This bit is self-clearing. The Auto-Negotiation process shall not be affected by clearing this bit to logic zero.

28.2.4.1.2 MII status register

The MII status register (register 1) includes information about all modes of operations supported by the Local Device's PHY, the status of Auto-Negotiation, and whether the Auto-Negotiation function is supported by the PHY or not. The definition for this register is provided in 22.2.4.2.

When read as a logic one, bit 1.5 indicates that the Auto-Negotiation process has been completed, and that the contents of registers 4, 5, and 6 are valid. When read as a logic zero, bit 1.5 indicates that the Auto-Negotiation process has not been completed, and that the contents of registers 4, 5, and 6 are meaningless. A PHY shall return a value of zero in bit 1.5 if Auto-Negotiation is disabled by clearing bit 0.12. A PHY shall also return a value of zero in bit 1.5 if it lacks the ability to perform Auto-Negotiation.

When read as logic one, bit 1.4 indicates that a remote fault condition has been detected. The type of fault as well as the criteria and method of fault detection is PHY specific. The Remote Fault bit shall be implemented with a latching function, such that the occurrence of a remote fault will cause the Remote Fault bit to become set and remain set until it is cleared. The Remote Fault bit shall be cleared each time register 1 is read via the management interface, and shall also be cleared by a PHY reset.

When read as a one, bit 1.3 indicates that the PHY has the ability to perform Auto-Negotiation. When read as a logic zero, bit 1.3 indicates that the PHY lacks the ability to perform Auto-Negotiation.

28.2.4.1.3 Auto-Negotiation advertisement register (register 4) (R/W)

This register contains the Advertised Ability of the PHY. (See table 28-2). The bit definition for the base page is defined in 28.2.1.2. On power-up, before Auto-Negotiation starts, this register shall have the following configuration: The Selector Field (4.4:0) is set to an appropriate code as specified in annex 28A. The Acknowledge bit (4.14) is set to logic zero. The Technology Ability Field (4.12:5) is set based on the values set in the MII status register (register 1) (1.15:11) or equivalent.

Only the bits in the Technology Ability Field that represent the technologies supported by the Local Device may be set. Any of the Technology Ability Field bits that may be set can also be cleared by management

Table 28-2—Advertisement register bit definitions

Bit(s)	Name	Description	R/W
4.15	Next Page	See 28.2.1.2	R/W
4.14	Reserved	Write as zero, ignore on read	RO
4.13	Remote Fault	See 28.2.1.2	R/W
4.12:5	Technology Ability Field	See 28.2.1.2	R/W
4.4:0	Selector Field	See 28.2.1.2	R/W

before a renegotiation. This can be used to enable management to Auto-Negotiate to an alternate common mode.

The management entity may initiate renegotiation with the Link Partner using alternate abilities by setting the Selector Field (4.4:0) and Technology Ability Field (4.12:5) to indicate the preferred mode of operation and setting the Restart Auto-Negotiation bit (0.9) in the control register (register 0) to logic one.

Any writes to this register prior to completion of Auto-Negotiation as indicated by bit 1.5 should be followed by a renegotiation for the new values to be properly used for Auto-Negotiation. Once Auto-Negotiation has completed, this register value may be examined by software to determine the highest common denominator technology.

28.2.4.1.4 Auto-Negotiation link partner ability register (register 5) (RO)

All of the bits in the Auto-Negotiation link partner ability register are read only. A write to the Auto-Negotiation link partner ability register shall have no effect.

This register contains the Advertised Ability of the Link Partner’s PHY. (See tables 28-3 and 28-4.) The bit definitions shall be a direct representation of the received Link Code Word (figure 28-7). Upon successful completion of Auto-Negotiation, status register (register 1) Auto-Negotiation Complete bit (1.5) shall be set to logic one. If the Next Page function is supported, the Auto-Negotiation link partner ability register may be used to store Link Partner Next Pages.

Table 28-3—Link partner ability register bit definitions (Base Page)

Bit(s)	Name	Description	R/W
5.15	Next Page	See 28.2.1.2	RO
5.14	Acknowledge	See 28.2.1.2	RO
5.13	Remote Fault	See 28.2.1.2	RO
5.12:5	Technology Ability Field	See 28.2.1.2	RO
5.4:0	Selector Field	See 28.2.1.2	RO

The values contained in this register are only guaranteed to be valid once Auto-Negotiation has successfully completed, as indicated by bit 1.5 or, if used with Next Page exchange, after the Page Received bit (6.1) has been set to logic one.

Table 28-4—Link partner ability register bit definitions (Next Page)

Bit(s)	Name	Description	R/W
5.15	Next Page	See 28.2.3.4	RO
5.14	Acknowledge	See 28.2.3.4	RO
5.13	Message Page	See 28.2.3.4	RO
5.12	Acknowledge 2	See 28.2.3.4	RO
5.11	Toggle	See 28.2.3.4	RO
5.10:0	Message/Unformatted Code Field	See 28.2.3.4	RO

NOTE—If this register is used to store Link Partner Next Pages, the previous value of this register is assumed to be stored by a management entity that needs the information overwritten by subsequent Link Partner Next Pages.

28.2.4.1.5 Auto-Negotiation expansion register (register 6) (RO)

All of the bits in the Auto-Negotiation expansion register are read only; a write to the Auto-Negotiation expansion register shall have no effect. (See table 28-5.)

Table 28-5—Expansion register bit definitions

Bit(s)	Name	Description	R/W	Default
6.15:5	Reserved	Write as zero, ignore on read	RO	0
6.4	Parallel Detection Fault	1 = A fault has been detected via the Parallel Detection function. 0 = A fault has not been detected via the Parallel Detection function.	RO/ LH	0
6.3	Link Partner Next Page Able	1 = Link Partner is Next Page able 0 = Link Partner is not Next Page able	RO	0
6.2	Next Page Able	1 = Local Device is Next Page able 0 = Local Device is not Next Page able	RO	0
6.1	Page Received	1 = A New Page has been received 0 = A New Page has not been received	RO/ LH	0
6.0	Link Partner Auto-Negotiation Able	1 = Link Partner is Auto-Negotiation able 0 = Link Partner is not Auto-Negotiation able	RO	0

Bits 6.15:5 are reserved for future Auto-Negotiation expansion.

The Parallel Detection Fault bit (6.4) shall be set to logic one to indicate that zero or more than one of the NLP Receive Link Integrity Test function, 100BASE-TX, or 100BASE-T4 PMAs have indicated link_status=READY when the autoneg_wait_timer expires. The Parallel Detection Fault bit shall be reset to logic zero on a read of the Auto-Negotiation expansion register (register 6).

The Link Partner Next Page Able bit (6.3) shall be set to logic one to indicate that the Link Partner supports the Next Page function. This bit shall be reset to logic zero to indicate that the Link Partner does not support the Next Page function.

The Next Page Able bit (6.2) shall be set to logic one to indicate that the Local Device supports the Next Page function. The Next Page Able bit (6.2) shall be set to logic zero if the Next Page function is not supported.

The Page Received bit (6.1) shall be set to logic one to indicate that a new Link Code Word has been received and stored in the Auto-Negotiation link partner ability register. The Page Received bit shall be reset to logic zero on a read of the Auto-Negotiation expansion register (register 6).

The Link Partner Auto-Negotiation Able bit (6.0) shall be set to logic one to indicate that the Link Partner is able to participate in the Auto-Negotiation function. This bit shall be reset to logic zero if the Link Partner is not Auto-Negotiation able.

28.2.4.1.6 Auto-Negotiation Next Page transmit register (register 7) (R/W)

The Auto-Negotiation Next Page Transmit register contains the Next Page Link Code Word to be transmitted when Next Page ability is supported. (See table 28-6.) The contents are defined in 28.2.3.4. On power-up, this register shall contain the default value of 2001H, which represents a Message Page with the Message Code set to Null Message. This value may be replaced by any valid Next Page Message Code that the device wishes to transmit. Writing to this register shall set `mr_next_page_loaded` to true.

Table 28-6—Next Page transmit register bit definitions

Bit(s)	Name	Description	R/W
7.15	Next Page	See 28.2.3.4	R/W
7.14	Reserved	Write as 0, ignore on read	RO
7.13	Message Page	See 28.2.3.4	R/W
7.12	Acknowledge 2	See 28.2.3.4	R/W
7.11	Toggle	See 28.2.3.4	RO
7.10:0	Message/Unformatted Code Field	See 28.2.3.4	R/W

28.2.4.1.7 State diagram variable to MII register mapping

The state diagrams of figures 28-14 to 28-17 generate and accept variables of the form “`mr_x`”, where x is an individual signal name. These variables comprise a management interface that may be connected to the MII management function or other equivalent function. Table 28-7 describes how the MII registers map to the management function interface signals.

28.2.4.2 Auto-Negotiation managed object class

The Auto-Negotiation Managed Object Class is defined in clause 30.

Table 28-7—State diagram variable to MII register mapping

State diagram variable	MII register
mr_adv_ability[16:1]	4.15:0 Auto-Negotiation advertisement register
mr_autoneg_complete	1.5 Auto-Negotiation Complete
mr_autoneg_enable	0.12 Auto-Negotiation Enable
mr_lp_adv_ability[16:1]	5.15:0 Auto-Negotiation link partner ability register
mr_lp_autoneg_able	6.0 Link Partner Auto-Negotiation Able
mr_lp_np_able	6.3 Link Partner Next Page Able
mr_main_reset	0.15 Reset
mr_next_page_loaded	Set on write to Auto-Negotiation Next Page Transmit register; cleared by Arbitration state diagram
mr_np_able	6.2 Next Page Able
mr_np_tx[16:1]	7.15:0 Auto-Negotiation Next Page Transmit Register
mr_page_rx	6.1 Page Received
mr_parallel_detection_fault	6.4 Parallel Detection Fault
mr_restart_negotiation	0.9 Auto-Negotiation Restart
set if Auto-Negotiation is available	1.3 Auto-Negotiation Ability

28.2.5 Absence of management function

In the absence of any management function, the advertised abilities shall be provided through a logical equivalent of mr_adv_ability[16:1]. A device shall comply with all Next Page function requirements, including the provision of the mr_np_able, mr_lp_np_able, and mr_next_page_loaded variables (or their logical equivalents), in order to permit the NP bit to be set to logic one in the transmitted Link Code Word.

NOTE—Storage of a valid base Link Code Word is required to prevent a deadlock situation where negotiation must start again while Next Pages are being transmitted. If a shared transmit register were used, then renegotiation could not occur when Next Pages were being transmitted because the base Link Code Word would not be available. This requirement can be met using a number of different implementations, including use of temporary registers or register stacks.

28.2.6 Technology-Dependent Interface

The Technology-Dependent Interface is the communication mechanism between each technology's PMA and the Auto-Negotiation function. Auto-Negotiation can support multiple technologies, all of which need not be implemented in a given device. Each of these technologies may utilize its own technology-dependent link integrity test function.

28.2.6.1 PMA_LINK.indicate

This primitive is generated by the PMA to indicate the status of the underlying medium. The purpose of this primitive is to give the PCS, repeater client, or Auto-Negotiation function a means of determining the validity of received code elements.

28.2.6.1.1 Semantics of the service primitive

PMA_LINK.indicate(link_status)

The link_status parameter shall assume one of three values: READY, OK, or FAIL, indicating whether the underlying receive channel is intact and ready to be enabled (READY), intact and enabled (OK), or not intact (FAIL). When link_status=FAIL or link_status=READY, the PMA_CARRIER.indicate and PMA_UNITDATA.indicate primitives are undefined.

28.2.6.1.2 When generated

A technology-dependent PMA and the NLP Receive Link Integrity Test state diagram (figure 28-17) shall generate this primitive to indicate the value of link_status.

28.2.6.1.3 Effect of receipt

The effect of receipt of this primitive shall be governed by the state diagrams of figure 28-16.

28.2.6.2 PMA_LINK.request

This primitive is generated by Auto-Negotiation to allow it to enable and disable operation of the PMA.

28.2.6.2.1 Semantics of the service primitive

PMA_LINK request(link_control)

The link_control parameter shall assume one of three values: SCAN_FOR_CARRIER, DISABLE, or ENABLE.

The link_control=SCAN_FOR_CARRIER mode is used by the Auto-Negotiation function prior to receiving any FLP Bursts or link_status=READY indications. During this mode, the PMA shall search for carrier and report link_status=READY when carrier is received, but no other actions shall be enabled.

The link_control=DISABLE mode shall be used by the Auto-Negotiation function to disable PMA processing.

The link_control=ENABLE mode shall be used by Auto-Negotiation to turn control over to a single PMA for all normal processing functions.

28.2.6.2.2 When generated

The Auto-Negotiation function shall generate this primitive to indicate to the PHY how to respond, in accordance with the state diagrams of figures 28-15 and 28-16.

Upon power-on or reset, if the Auto-Negotiation function is enabled (mr_autoneg_enable=true) the PMA_LINK request(DISABLE) message shall be issued to all technology-dependent PMAs. If Auto-Negotiation is disabled at any time including at power-on or reset, the state of PMA_LINK.request(link_control) is implementation dependent.

28.2.6.2.3 Effect of receipt

The effect of receipt of this primitive shall be governed by the NLP Receive Link Integrity Test state diagram (figure 28-17) and the receiving technology-dependent link integrity test function, based on the intent specified in the primitive semantics.

28.3 State diagrams and variable definitions

The notation used in the state diagrams (figures 28-14 to 28-17) follows the conventions in 21.5. State diagram variables follow the conventions of 21.5.2 except when the variable has a default value. Variables in a state diagram with default values evaluate to the variable default in each state where the variable value is not explicitly set. Variables using the “mr_x” notation do not have state diagram defaults; however, their appropriate initialization conditions when mapped to the MII interface are covered in 28.2.4 and 22.2.4. The variables, timers, and counters used in the state diagrams are defined in 28.3, 14.2.3, and 28.2.6.

Auto-Negotiation shall implement the Transmit state diagram, Receive state diagram, Arbitration state diagram, and NLP Receive Link Integrity Test state diagram as depicted in 28.3. Additional requirements to these state diagrams are made in the respective functional requirements sections. Options to these state diagrams clearly stated as such in the functional requirements sections or state diagrams shall be allowed. In the case of any ambiguity between stated requirements and the state diagrams, the state diagrams shall take precedence.

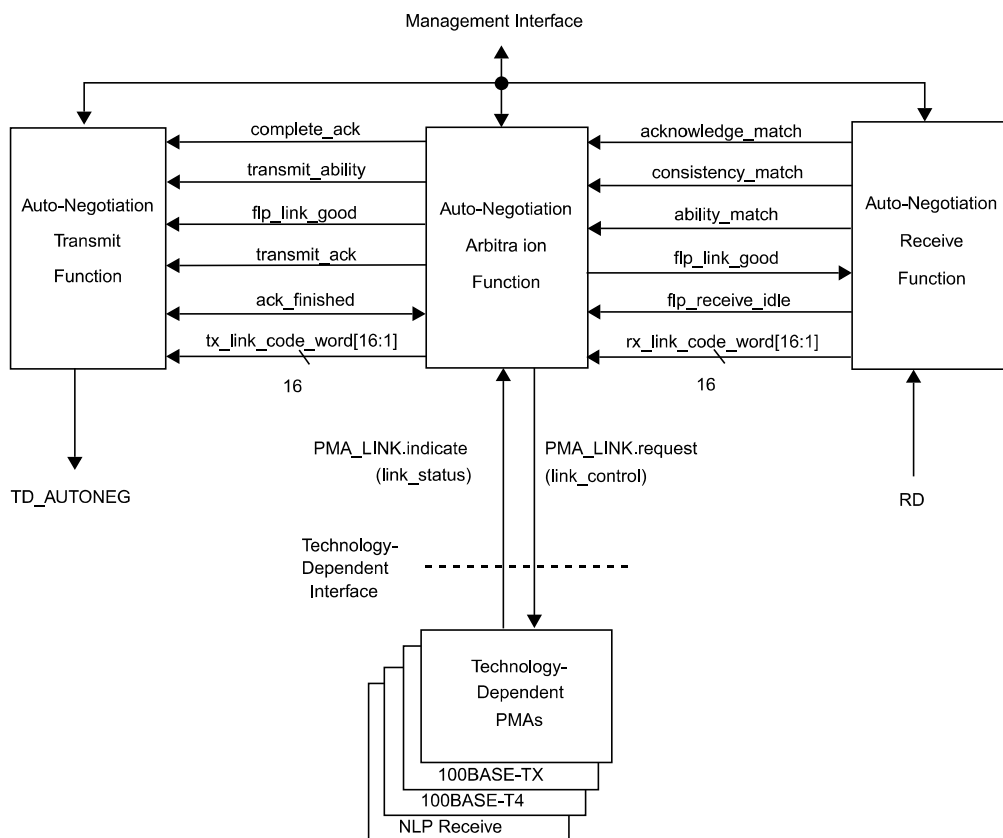


Figure 28-13—Functional reference diagram

28.3.1 State diagram variables

A variable with “_[x]” appended to the end of the variable name indicates a variable or set of variables as defined by “x”. “x” may be as follows:

- all; represents all specific technology-dependent PMAs supported in the Local Device and the NLP

- Receive Link Integrity Test state diagram.
- HCD; represents the single technology-dependent PMA chosen by Auto-Negotiation as the highest common denominator technology through the Priority Resolution or Parallel Detection function. To select 10BASE-T, LIT is used instead of NLP to enable the full 10BASE-T Link Integrity Test function state diagram.
- notHCD; represents all technology-dependent PMAs not chosen by Auto-Negotiation as the highest common denominator technology through the Priority Resolution or Parallel Detection function.
- TX; represents that the 100BASE-TX PMA is the signal source.
- T4; represents that the 100BASE-T4 PMA is the signal source.
- NLP; represents that the NLP Receive Link Integrity Test function is the signal source.
- PD; represents all of the following that are present: 100BASE-TX PMA, 100BASE-T4 PMA, and the NLP Receive Link Integrity Test state diagram.
- LIT; represents the 10BASE-T Link Integrity Test function state diagram is the signal source or destination.

Variables with [16:1] appended to the end of the variable name indicate arrays that can be directly mapped to 16-bit registers. For these variables, “[x]” indexes an element or set of elements in the array, where “[x]” may be as follows:

- Any integer.
- Any variable that takes on integer values.
- NP; represents the index of the Next Page bit.
- ACK; represents the index of the Acknowledge bit.
- RF; represents the index of the Remote Fault bit.

Variables of the form “mr_x”, where x is a label, comprise a management interface that is intended to be connected to the MII Management function. However, an implementation-specific management interface may provide the control and status function of these bits.

ability_match

Indicates that three consecutive Link Code Words match, ignoring the Acknowledge bit. Three consecutive words are any three words received one after the other, regardless of whether the word has already been used in a word-match comparison or not.

Values: false; three matching consecutive Link Code Words have not been received, ignoring the Acknowledge bit (default).
true; three matching consecutive Link Code Words have been received, ignoring the Acknowledge bit.

NOTE—This variable is set by this variable definition; it is not set explicitly in the state diagrams.

ack_finished

Status indicating that the final remaining_ack_cnt Link Code Words with the Ack bit set have been transmitted.

Values: false; more Link Code Words with the Ack bit set to logic one must be transmitted.
true; all remaining Link Code Words with the Ack bit set to logic one have been transmitted.

acknowledge_match

Indicates that three consecutive Link Code Words match and have the Acknowledge bit set. Three consecutive words are any three words received one after the other, regardless of whether the word has already been used in a word match comparison or not.

Values: false; three matching and consecutive Link Code Words have not been received with the