128. Physical Medium Dependent sublayer and baseband medium, type 2.5GBASE-KX

128.1 Overview

This clause specifies the 2.5GBASE-KX PMD and baseband medium. When forming a complete PHY, a PMD shall be combined with the appropriate sublayers (see Table 128–1), and with the management functions that are optionally accessible through the management interface defined in Clause 45~~Clause 45~~.

Table 128–1—Physical Layer clauses associated with the 2.5GBASE-KX PMD

Associated clause	2.5GBASE-KX
46—XGMII[a]	Optional
73—Auto-Negotiation for Backplane Ethernet	Optional
78—Energy-Efficient Ethernet	Optional
127—2.5GBASE-X PCS/PMA	Required

[a]The XGMII is an optional interface. However, if the XGMII is not implemented, a conforming implementation must behave functionally as though the RS and XGMII were present.

A 2.5GBASE-KX PHY with the optional Energy-Efficient Ethernet (EEE) capability may optionally enter the Low Power Idle (LPI) mode to conserve energy during periods of low link utilization. The “Assert LPI” request at the XGMII is encoded in the transmitted symbols. Detection of LPI signaling in the received symbols is indicated as “Assert LPI” at the XGMII. Upon the detection of “Assert LPI” at the XGMII, an energy-efficient 2.5GBASE-KX PHY continues transmitting for a predefined period, then ceases transmission and deactivates transmit functions to conserve energy. The PHY periodically transmits during this quiet period to allow the remote PHY to refresh its receiver state (e.g., timing recovery, adaptive filter coefficients) and thereby track long-term variations in the timing of the link or the underlying channel characteristics. If, during the quiet or refresh periods, normal interframes resume at the XGMII, the PHY reactivates transmit functions and initiates transmission. This transmission will be detected by the remote PHY, causing it to also exit the LPI mode.

128.2 Physical Medium Dependent (PMD) service interface

The following specifies the services provided by the 2.5GBASE-KX PMDs. These PMD sublayer service interfaces are described in an abstract manner and do not imply any particular implementation.

The PMD Service Interface supports the exchange of encoded and scrambled 8B/10B~~64B/66B~~ blocks between the PMA and PMD entities. The PMD translates the serialized data of the PMA to and from signals suitable for the specified medium.

The following primitives are defined:

PMD_UNITDATA.request(tx_bit)
PMD_UNITDATA.indication(rx_bit)
PMD_SIGNAL.indication(SIGNAL_DETECT)

If EEE is supported, the following primitives are also defined on the PMD Service Interface:

PMD_RXQUIET.request(rx_quiet)
PMD_TXQUIET.request(tx_quiet)

These messages affect the PCS variables as described in 127.2.6.1.6.

128.2.1 PMD_UNITDATA.request

This primitive defines the transfer of a serial data stream from the PMA to the PMD.

128.2.1.1 Semantics of the service primitive

PMD_UNITDATA.request(tx_bit)

The data conveyed by PMD_UNITDATA.request is a continuous stream of bits. The tx_bit parameter can take one of two values: ONE or ZERO.

128.2.1.2 When generated

The PMA continuously sends the appropriate stream of bits to the PMD for transmission on the medium, at ~~a nominal 3.125 GBd~~ signaling speed for 2.5GBASE-KX PMD types.

128.2.1.3 Effect of receipt

Upon receipt of this primitive, the PMD converts the specified stream of bits into the appropriate signals on the MDI.

128.2.2 PMD_UNITDATA.indication

This primitive defines the transfer of data (in the form of serialized data) from the PMD to the PMA.

128.2.2.1 Semantics of the service primitive

PMD_UNITDATA.indication(rx_bit)

The data conveyed by PMD_UNITDATA.indication is a continuous stream of bits. The rx_bit parameter can take one of two values: ONE or ZERO.

128.2.2.2 When generated

The PMD continuously sends stream of bits to the PMA corresponding to the signals received from the MDI.

128.2.2.3 Effect of receipt

The effect of receipt of this primitive by the client is unspecified by the PMD sublayer.

128.2.3 PMD_SIGNAL.indication

This primitive is generated by the PMD to indicate the status of the signal being received from the MDI.

128.2.3.1 Semantics of the service primitive

PMD_SIGNAL.indication(SIGNAL_DETECT)

The SIGNAL_DETECT parameter can take on one of two values: OK or FAIL, indicating whether the PMD is detecting signal at the receiver (OK) or not (FAIL). When SIGNAL_DETECT = FAIL, then rx_bit is undefined, but consequent actions based on PMD_UNITDATA.indication, where necessary, interpret rx_bit as a logic ZERO.

NOTE– SIGNAL_DETECT = OK does not guarantee that PMD_UNITDATA.indication(rx_bit) is known good. It is possible for a poor quality link to provide sufficient signal for a SIGNAL_DETECT = OK indication and still not meet the ~~10^{-12}~~ BER objective.

128.2.3.2 When generated

The PMD generates this primitive to indicate a change in the value of SIGNAL_DETECT. If the MDIO interface is implemented, then PMD_global_signal_detect shall be continuously set to the value of SIGNAL_DETECT.

128.2.3.3 Effect of receipt

The effect of receipt of this primitive by the client is unspecified by the PMD sublayer.

128.2.4 PMD_RXQUIET.request

This primitive is generated by the PCS Receive Process when EEE is supported to indicate that the input signal is quiet and the PMA and PMD receiver may go into low power mode. When EEE is not supported, the primitive is never invoked and the PMD behaves as if rx_quiet = FALSE.

128.2.4.1 Semantics of the service primitive

PMD_RXQUIET.request(rx_quiet)

The rx_quiet parameter takes on one of two values: TRUE or FALSE.

128.2.4.2 When generated

The PCS generates this primitive to request the appropriate PMD receive LPI state.

128.2.4.3 Effect of receipt

This variable is from the receive process of the PCS to control the power-saving function of the local PMD receiver. The ~~1000BASE-KX~~ 2.5GBASE-KXPHY receiver should put unused functional blocks into a low power state to save energy.

128.2.5 PMD_TXQUIET.request

This primitive is generated by the PCS Transmit Process when EEE is supported to indicate that the PMA and PMD transmit functions may go into a low power mode and to disable the PMD transmitter. See 128.6.5. When EEE is not supported, the primitive is never invoked and the PMD behaves as if tx_quiet = FALSE.

128.2.5.1 Semantics of the service primitive

PMD_TXQUIET.request(tx_quiet)

The tx_quiet parameter takes on one of two values: TRUE or FALSE.

128.2.5.2 When generated

The PCS generates this primitive to request the appropriate PMD transmit LPI state.

128.2.5.3 Effect of receipt

This primitive affects operation of the PMD Transmit disable function as described in 128.6.5. The 2.5GBASE-KX PHY transmitter should put unused functional blocks into a lower power state to save energy.

128.3 PCS requirements for Auto-Negotiation (AN) service interface

The PCS associated with this PMD ~~shall~~may optionally support the AN service interface primitive AN_LINK.indication as defined in 73.9.

128.4 Delay constraints

Predictable operation of the MAC Control PAUSE operation (Clause 31, Annex 31B) demands that there be an upper bound on the propagation delays through the network. This implies that MAC, MAC Control sublayer, and PHY implementers must consider the delay maxima, and that network planners and administrators consider the delay constraints regarding the physical topology and concatenation of devices.

The sum of transmit and receive delays contributed by the 2.5GBASE-KX PMD and medium shall be no more than 256 bit times. It is assumed that the round-trip delay through the medium is less than or equal to 40 bit times.

128.5 PMD MDIO function mapping

The optional MDIO capability described in Clause 45 defines several variables that provide control and status information for and about the PMD. If the MDIO is implemented, it shall map MDIO control variables to PMD control variables as shown in Table 128–2, and MDIO status variables to PMD status variables as shown in Table 128–3.

Table 128–2—MDIO/PMD control variable mapping

MDIO control variable	PMA/PMD register name	Register/ bit number	PMD control variable
Reset	Control register 1	1.0.15	PMD_reset
PMD Transmit Disable	1000BASE-KX/ 2.5GBASE-KX control register	1.160.0	PMD_transmit_disable

Table 128–3—MDIO/PMD status variable mapping

MDIO status variable	PMA/PMD register name	Register/ bit number	PMD status variable
Fault	Status register 1	1.1.7	PMD_fault
Transmit fault ability	1000BASE-KX/ 2.5GBASE-KX status register	1.161.13	PMD_Transmit_fault_ability
Receive fault ability	1000BASE-KX/ 2.5GBASE-KX status register	1.161.12	PMD_Receive_fault_ability
Transmit fault	1000BASE-KX/ 2.5GBASE-KX status register	1.161.11	PMD_transmit_fault
Receive fault	1000BASE-KX/ 2.5GBASE-KX status register	1.161.10	PMD_receive_fault
PMD transmit disable ability	1000BASE-KX/ 2.5GBASE-KX status register	1.161.8	PMD_transmit_disable_ability
Signal detect from PMD	1000BASE-KX/ 2.5GBASE-KX status register	1.161.0	PMD_signal_detect

128.6 PMD functional specifications

128.6.1 Link block diagram

For purposes of system conformance, the PMD sublayer is standardized at test points TP1 and TP4 as shown in Figure 128–1. The transmitter and receiver blocks include all off-chip components associated with the respective block. For example, external AC-coupling capacitors, if required, are to be included in the receiver block.

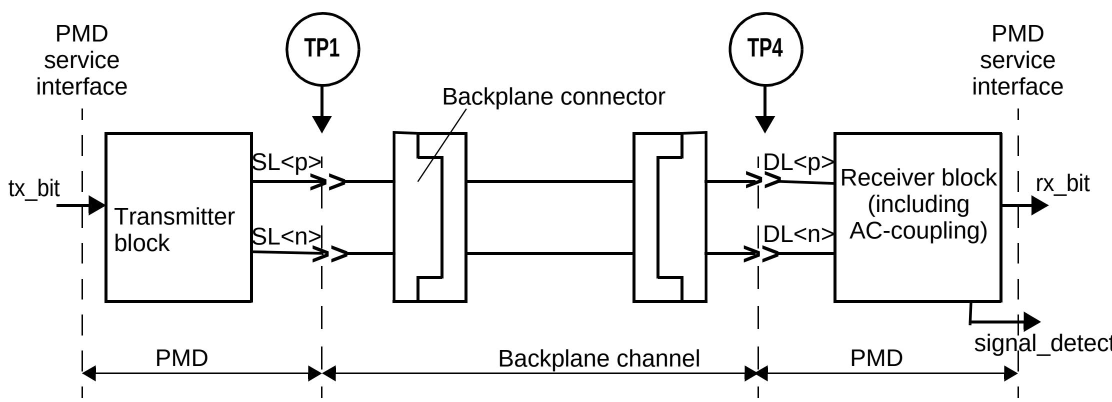

Figure 128–1—Link block diagram

The electrical path from the transmitter block to TP1, and from TP4 to the receiver block, will affect link performance and the measured values of electrical parameters used to verify conformance to this standard. Therefore, it is recommended that this path be carefully designed.

128.6.2 PMD transmit function

The PMD Transmit function shall convey the bits requested by the PMD service interface message PMD_UNITDATA.request(tx_bit) to the MDI according to the electrical specifications in 128.7.1. A positive output voltage of SL<p> minus SL<n> (differential voltage) shall correspond to tx_bit = ONE.

128.6.3 PMD receive function

The PMD Receive function shall convey the bits received at the MDI in accordance with the electrical specifications of 128.7.2 to the PMD service interface using the message PMD_UNITDATA.indication(rx_bit). A positive input voltage of DL<p> minus DL<n> (differential voltage) shall correspond to rx_bit = ONE.

128.6.4 PMD signal detect function

For 2.5GBASE-KX operation PMD signal detect is mandatory if EEE is supported. When EEE is not supported, the PMD signal detect is optional for 2.5GBASE-KX and its definition is beyond the scope of this specification. When PMD signal detect is not implemented, the value of SIGNAL_DETECT shall be set to OK for purposes of management and signaling of the primitive.

If EEE is supported, a local PMD signal detect function shall report to the PMD service interface using the message PMD_SIGNAL.indication(SIGNAL_DETECT). This message is signaled continuously. For EEE, the SIGNAL_DETECT parameter can take on one of two values, OK or FAIL, indicating whether the PMD is detecting electrical energy at the receiver (OK) or not (FAIL). When SIGNAL_DETECT = FAIL, PMD_UNITDATA.indication is undefined. The signal energy from a compliant transmitter shall set SIGNAL_DETECT to OK within 750 ns when transitioning from LPI quiet to active and set SIGNAL_DETECT to FAIL within 750 ns when transitioning from active to LPI quiet.

128.6.5 PMD transmit disable function

The PMD_transmit_disable function is mandatory if EEE is supported and is otherwise optional. When implemented, it allows the transmitter to be disabled with a single variable.

a) When the PMD_transmit_disable variable is set to ONE, this function shall turn off the transmitter such that it drives a constant level (i.e., no transitions) and does not exceed the maximum differential peak-to-peak output voltage specified in Table 128–4.
b) If a PMD_fault (128.6.7) is detected, then the PMD may turn off the electrical transmitter.
c) Loopback, as defined in 128.6.6, shall not be affected effected by PMD_transmit_disable.
d) For EEE capability, the PMD_transmit_disable function shall turn off the transmitter after tx_quiet is asserted within the time and voltage level specified in 128.7.1.4. The PMD_transmit_disable function shall turn on the transmitter after tx_quiet is de-asserted within a time and voltage level specified in 128.7.1.4.

128.6.6 Loopback mode

Loopback mode shall be provided for the 2.5GBASE-KX PMA/PMD by the transmitter and receiver of a device as a test function to the device. When loopback mode is selected, transmission requests passed to the transmitter are shunted directly to the receiver, overriding any signal detected by the receiver on its attached link. Transmitter operation shall be independent of loopback mode. A device must be explicitly placed in loopback mode because loopback mode is not the normal mode of operation of a device. The method of implementing loopback mode is not defined by this standard.

Control of the loopback function is specified in 45.2.1.1.5.

NOTE 1—The signal path that is exercised in the loopback mode is implementation specific, but it is recommended that this signal path encompass as much of the circuitry as is practical. The intention of providing this loopback mode of operation is to permit diagnostic or self-test functions to test the transmit and receive data paths using actual data. Other loopback signal paths may also be enabled independently using loopback controls within other devices or sublayers.

NOTE 2—Placing a network port into loopback mode can be disruptive to a network.

128.6.7 PMD fault function

If the MDIO is implemented, and the PMD has detected a local fault, the PMD shall set PMD_fault to ONE; otherwise, the PMD shall set PMD_fault to ZERO.

128.6.8 PMD transmit fault function

If the MDIO is implemented, and the PMD has detected a local fault on the transmitter, the PMD shall set the PMD_transmit_fault variable to ONE; otherwise, the PMD shall set PMD_transmit_fault to ZERO.

128.6.9 PMD receive fault function

If the MDIO is implemented, and the PMD has detected a local fault on the receiver, the PMD shall set the PMD_receive_fault variable to ONE; otherwise, the PMD shall set PMD_receive_fault to ZERO.

128.6.10 PMD LPI function

The PMD LPI function responds to the transitions between Active, Sleep, Quiet, Refresh, and Wake states via the PMD_TXQUIET and PMD_RXQUIET requests. Implementation of the function is optional. EEE capabilities and parameters are advertised during the Backplane Auto-N~~n~~egotiation as described in 45.2.7.13. The transmitter on the local device informs the link partner's receiver when to sleep, refresh, and wake. The local receiver's transitions are controlled by the link partner's transmitter and change independently from the local transmitter's states and transitions.

The transmitter sends /LI/ ordered sets during the sleep and refresh states, disables the transmitter during quiet, and forwards /I/ during the wake phase.

If EEE is supported, the PMD transmit function enters into a low power mode when tx_quiet is set to TRUE and exits when tx_quiet is set to FALSE. While tx_quiet is TRUE the PMD transmitter functional blocks should be deactivated to conserve energy. The PMD receive function enters into a low power mode when rx_quiet is set to TRUE and exits when rx_quiet is set to FALSE. While rx_quiet is TRUE the PMD receiver functional blocks should be deactivated to conserve energy.

128.7 2.5GBASE-KX electrical characteristics

128.7.1 Transmitter characteristics

Transmitter characteristics at TP1 are summarized in Table 128–4 and detailed in 128.7.1.1 through 128.7.1.10.

Table 128–4—Transmitter characteristics for 2.5GBASE-KX

Parameter	Subclause reference	Value	Units
Signaling speed	128.7.1.3	3.125 ± 100 ppm	GBd
Differential peak-to-peak output voltage (max)	128.7.1.4	1200	mV
Differential peak to peak output voltage when TX is disabled		30	mV
Common-mode voltage limits	128.7.1.4	0 to 1.9	V
Differential output return loss (min)	128.7.1.5	See the Equation (128–3) and the Equation (128–4)	dB
Common mode output return loss (min)	128.7.1.6	See the Equation (128–5) and the Equation (128–6)	dB
Transition time (20%–80%)	128.7.1.7	30 to 100	ps
Maximum Output jitter (peak-to-peak) Random jitter Deterministic jitter Duty Cycle Distortion[a] Total jitter[b]	128.7.1.9	 0.20 0.12 0.035 0.35	 UI UI UI UI

[a]Duty Cycle Distortion is considered part of deterministic jitter distribution.
[b]Jitter is specified at BER 10^{-12}.

128.7.1.1 Test fixtures

The test fixture of Figure 128–2, or its functional equivalent, is required for measuring the transmitter specifications described in 128.7.1, with the exception of return loss.

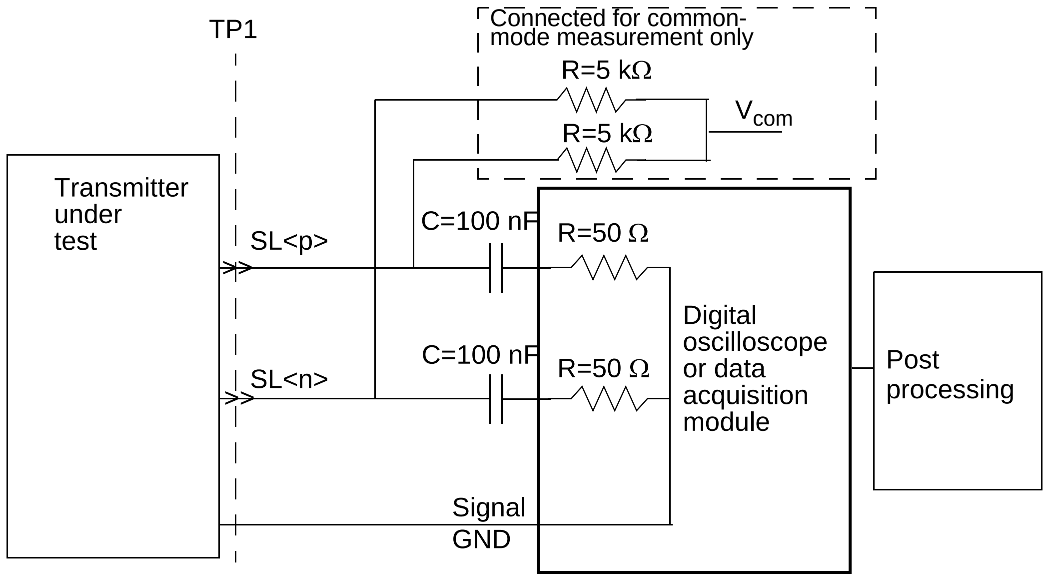

Figure 128–2—Transmit test fixture for 2.5GBASE-KX

128.7.1.2 Test fixture ~~impedance~~characteristics

The differential load impedance applied to the transmitter output by the test fixture depicted in Figure 128–2 shall be 100 Ω.~~The differential~~ The differential return loss, in dB with *f* in MHz, of the test fixture shall meet the requirements of Equation (128–1) and Equation (128–2).

$$Return\_Loss(f) \geq 20 \qquad (128–1)$$

for 100 MHz ≤ *f* < 1562.5 MHz and

$$Return\_Loss(f) \geq 20 - 20\log_{10}\left(\frac{f}{1562.5}\right) \qquad (128–2)$$

for 1562.5 MHz ≤ *f* ≤ 2000 MHz.

128.7.1.3 Signaling speed

The 2.5GBASE-KX signaling speed shall be ~~3.125 GBd ± 100 ppm~~.

128.7.1.4 Output amplitude

The differential output voltage is constrained via the transmitter output waveform requirements specified in 128.7.1.10. For a 1010 pattern, the peak-to-peak differential output voltage shall be ~~less than 1200 mV. The~~

~~transmitter output voltage shall be less than or equal to 30mV peak-to-peak, when disabled~~. The differential output voltage test pattern shall consist of no fewer than eight symbols of alternating polarity.

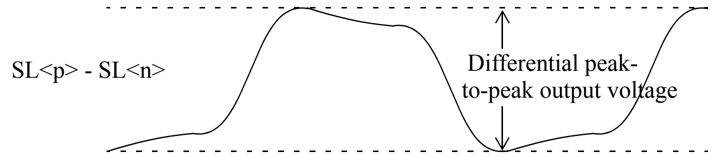

Figure 128–3—Transmitter differential peak-to-peak output voltage definition

NOTE—SL<p> and SL<n> are the positive and negative sides of the differential signal pair.

NOTE– See Figure 128–3 for an illustration of the definition of differential peak-to-peak output voltage. DC-referenced voltage levels are not defined since the receiver is AC-coupled. The common-mode voltage of SL<p> and SL<n> ~~shall be between 0.20 and 1.9V~~ with respect to signal ground as measured at V_{com} in Figure 128–21.

For EEE capability, the transmitter~~'s differential peak-to-peak output voltage~~ shall ~~be less than or equal to 30 mV~~ within 500 ns of tx_mode being set to QUIET and remain so while tx_mode is set to QUIET. Furthermore, the transmitter's differential peak-to-peak output voltage shall be greater than 720 mV within 500 ns of tx_mode being set to ALERT. The transmitter output shall be fully compliant within 5s after tx_mode is set to DATA. During LPI mode, the common-mode shall be maintained to within ± 150 mV of the pre-LPI value.

128.7.1.5 Differential output return loss

For frequencies from 100 MHz to 2000 MHz, the differential return loss, in dB with f in MHz, of the transmitter shall meet the requirements of ~~Equation (128–3) and Equation (128–4)~~. This output impedance requirement applies to all valid output levels. The reference impedance for differential return loss measurements shall be 100 Ω.

$$Return\_Loss(f) \geq 10 \quad (128\text{–}3)$$

for 100 MHz ≤ f < 625 MHz and,

$$Return\_Loss(f) \geq 10 - 10\log_{10}\left(\frac{f}{625}\right) \quad (128\text{–}4)$$

for 625 MHz ≤ f ≤ 2000 MHz.

The minimum differential output return loss is shown in Figure 128–4.

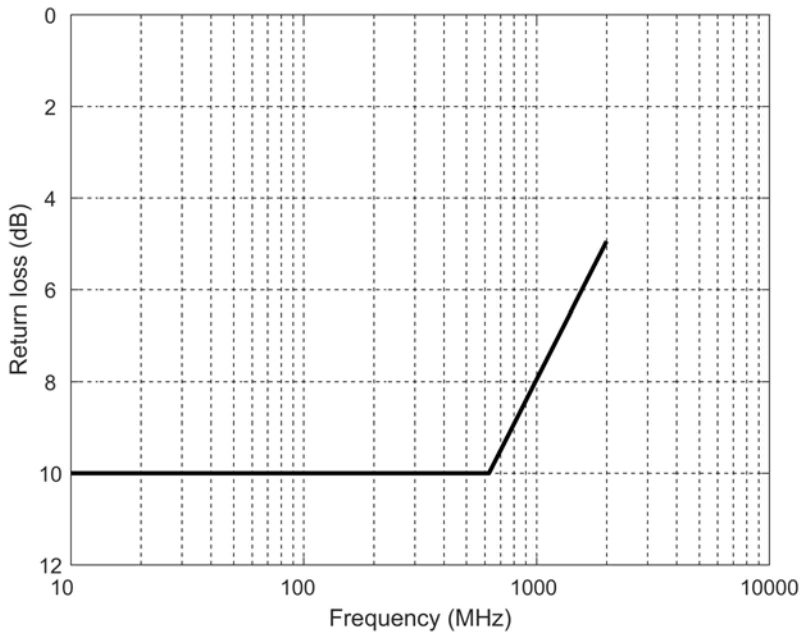

Figure 128–4—Transmitter differential mode return loss

128.7.1.6 Common mode output return loss

The transmitter common-mode return loss shall meet the requirements of ~~Equation (128–5) and Equation (128–6)~~. The reference impedance for common-mode return loss measurements is 25 Ω.

$$Return\_loss(f) \geq 7 \quad (128–5)$$

for 100 MHz ≤ f < 625 MHz and,

$$Return\_loss(f) \geq 7 - 10\log_{10}\left(\frac{f}{625}\right) \quad (128–6)$$

for 625 MHz ≤ f ≤ 2000 MHz.

The minimum common mode~~differential~~ output return loss is shown in Figure 128–5.

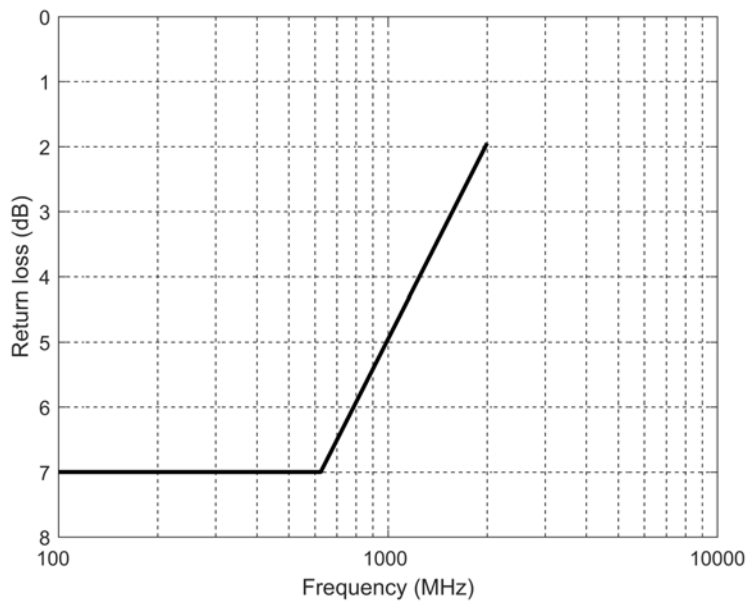

Figure 128–5—Transmitter common~~differential~~ mode return loss

128.7.1.7 Transition time

The rising edge transition time shall be ~~between~~from 30 ps ~~and~~to 100 ps ~~as measured at the 20% and 80% levels of~~ the peak-to-peak differential value of the waveform using the high-frequency test pattern of 36A.1~~128B.1~~.

The falling edge transition time shall be ~~between~~from 30 ps ~~and~~to 100 ps ~~as measured at the 80% and 20% levels of~~ the peak-to-peak differential value of the waveform using the high-frequency test pattern of ~~128B.1.~~

128.7.1.8 Transmit jitter test requirements

Transmit jitter is defined with respect to a test procedure resulting in a BER bathtub curve such as that described in Annex 48B.3. For the purpose of jitter measurement, the effect of a single-pole high-pass filter with a 3 dB point at 1.875 MHz is applied to the jitter. The data pattern for jitter measurements ~~shall be the test patterns 2 or 3 as defined in 52.9.1.1~~shall be a low frequency test pattern as defined in 36A.2. Crossing times are defined with respect to the mid-point (0 V) of the AC-coupled differential signal. The duty cycle distortion test pattern shall consist of no fewer than eight symbols of alternating polarity.

128.7.1.9 Transmit jitter

The transmitter ~~shall have a maximum total jitter of 0.35 UI peak-to-peak, composed of a maximum deterministic c~~Component ~~of 0.15 UI peak-to-peak~~s ~~and a maximum random component of 0.20 UI peak-to-peak.~~ Duty cycle distortion (DCD) is considered a component of deterministic jitter ~~and shall not exceed 0.035 UI peak-to-peak~~. The peak-to-peak duty cycle distortion is defined as the absolute value of the difference in the mean pulse width of a 1 pulse or the mean pulse width of a 0 pulse (as measured at the mean of the high- and low-voltage levels in a clocklike repeating 0101 bit sequence) and the nominal pulse width. Jitter specifications are specified for BER 10^{-12}. Transmit jitter test requirements are specified in 128.7.1.8.

NOTE– Duty Cyle Distortion is also referred to as Even-odd jitter (see 92.8.3.8.1).

128.7.1.10 ~~Transmitter output waveform~~

~~The test pattern for the transmitter output waveform is the square wave test pattern defined in 52.9.1.2, with a run of at least eight consecutive ones. The transmitter output waveform test is based on the voltages v1 and v2, which shall be measured as shown in Figure 128–6 and described below.~~

Figure 128–6—~~Transmitter output waveform~~

~~T = Symbol period~~
~~t1 = zero crossing of the first rising edge of AC coupled signal~~
~~t2 = Zero crossing of the falling edge of the AC coupled signal~~
~~t3 = Zero crossing of the second rising edge of the AC coupled signal~~
~~v1 = positive steady state voltage measured as the average voltage in the interval t1 to t2~~
~~v2 = negative steady state voltage measured as the average voltage in the interval of t2 to t3~~

128.7.2 Receiver characteristics

Receiver characteristics at TP4 are summarized in Table 128–5 and detailed in 128.7.2.1 through 128.7.2.5.

Table 128–5—Receiver characteristics for 2.5GBASE-KX

Parameter	Subclause reference	Value	Units
Bit error ratio	128.7.2.1	10^{-12}	
Signaling speed	128.7.2.2	3.125 ± 100 ppm	GBd
Receiver coupling	128.7.2.3	AC	
Differential input peak-to-peak amplitude (max.)[a]	128.7.2.4	1200	mV
Differential input return loss (min.)[b]	128.7.2.5	See Equation (128–3) and Equation (128–4)	dB

[a]The receiver shall tolerate amplitudes up to a maximum voltage of 1200mV without permanent damage.
[b]Relative to 100 Ω differential.

128.7.2.1 Receiver interference tolerance

The receiver interference tolerance consists of the test as described in Annex ~~128B~~ with the parameters specified in Table 128–6. The data pattern for the interference tolerance test shall be the test patterns 2 or 3 as defined in 59.9.1.1. The receiver shall satisfy the requirements for interference tolerance specified in Annex ~~128B~~ for the test.

Table 128–6—2.5GBASE-X interference tolerance parameters

Parameter	Value	Units
Target BER	10^{-12}	
m_{TC}[a] (min.)	1	
Amplitude of broadband noise (min. RMS)	10.2	mV
Applied transition time (20%–80%, min.)	100	ps
Applied sinusoidal jitter (min. peak-to-peak)	0.12	UI
Applied random jitter (min. peak-to-peak)[b]	0.2	UI
Applied duty cycle distortion (min. peak-to-peak)	0.035	UI

[a] m_{TC} is defined in Equation ~~(128B–6)~~ in Annex ~~128B~~.
[b] Applied random jitter is specified at a BER of 10^{-12}.

128.7.2.2 Signaling speed range

~~A~~ 2.5GBASE-X receiver shall comply with the requirements of Table 128–5 ~~for any signaling speed in the range 3.125 GBd ± 100 ppm~~.

128.7.2.3 AC-coupling

The 2.5GBASE-X receiver shall be AC-coupled to the backplane to allow for maximum interoperability between various 2.5 Gb/s components. AC-coupling is considered to be part of the receiver for the purposes of this specification unless explicitly stated otherwise. It should be noted that there may be various methods for AC-coupling in actual implementations.

NOTE—It is recommended that the maximum value of the coupling capacitors be limited to 100 nF. This will limit the inrush currents to the receiver that could damage the receiver circuits when repeatedly connected to transmit modules with a higher voltage level.

128.7.2.4 Input signal amplitude

2.5GBASE-X receivers shall accept differential input signal peak-to-peak amplitudes produced by compliant transmitters connected without attenuation to the receiver, and still meet the BER requirement specified in 128.7.2.1. Note that this may be larger than the ~~1200 mV~~ differential maximum of 128.7.1.4 due to the actual transmitter output and receiver input impedances. The input impedance of a receiver can cause the minimum signal into a receiver to differ from that measured when the receiver is replaced with a 100 Ω test load. Since the receiver is AC-coupled, the absolute voltage levels with respect to the receiver ground are dependent on the receiver implementation.

128.7.2.5 Differential input return loss

For frequencies from 100 MHz to 2000 MHz, the differential return loss, in dB with *f*~~f~~ in MHz, of the receiver shall meet the requirements of ~~Equation (128-3) and Equation (128-4);~~. This return loss requirement applies to all valid input levels. ~~The reference impedance for differential return loss measurements shall be 100 Ω.~~

128.8 Interconnect characteristics

Informative interconnect characteristics are provided in ~~Annex 128B~~Annex 128C.

128.9 Environmental specifications

128.9.1 General safety

All equipment that meets the requirements of this standard shall conform to applicable sections (including isolation requirements) of IEC 60950-1.

128.9.2 Network safety

The designer is urged to consult the relevant local, national, and international safety regulations to ensure compliance with the appropriate requirements.

128.9.3 Installation and maintenance guidelines

It is recommended that sound installation practice, as defined by applicable local codes and regulations, be followed in every instance in which such practice is applicable.

128.9.4 Electromagnetic compatibility

A system integrating the 2.5GBASE-KX PHY shall comply with applicable local and national codes for the limitation of electromagnetic interference.

128.9.5 Temperature and humidity

A system integrating the 2.5GBASE-KX PHY is expected to operate over a reasonable range of environmental conditions related to temperature, humidity, and physical handling (such as shock and vibration). Specific requirements and values for these parameters are considered to be beyond the scope of this standard.

128.10 Protocol implementation conformance statement (PICS) proforma for Clause 128, Physical Medium Dependent sublayer and baseband medium, type 2.5GBASE-KX[2]

128.10.1 Introduction

The supplier of a protocol implementation that is claimed to conform to IEEE Std 802.3, Clause 128, Physical Medium Dependent sublayer and baseband medium type 1000BASE-KX, shall complete the following protocol implementation conformance statement (PICS) proforma. A detailed description of the symbols used in the PICS proforma, along with instructions for completing the PICS proforma, can be found in Clause 21.

128.10.2 Identification

128.10.2.1 Implementation identification

Supplier	
Contact point for inquiries about the PICS	
Implementation Name(s) and Version(s)	
Other information necessary for full identification—e.g., name(s) and version(s) for machines and/or operating systems; System Name(s)	
NOTE 1—Only the first three items are required for all implementations; other information may be completed as appropriate in meeting the requirements for the identification. NOTE 2—The terms Name and Version should be interpreted appropriately to correspond with a supplier's terminology (e.g., Type, Series, Model).	

128.10.2.2 Protocol summary

Identification of protocol standard	IEEE Std 802.3cb-~~20xx~~20xx, Clause 128, Physical Medium Dependent sublayer and baseband medium type 2.5GBASE-KX
Identification of amendments and corrigenda to this PICS proforma that have been completed as part of this PICS	
Have any Exception items been required? No [ ] Yes [ ] (See ; the answer Yes means that the implementation does not conform to IEEE Std 802.3cb-~~20xx~~20xx.)	
Date of Statement	

[2]*Copyright release for PICS proformas:* Users of this standard may freely reproduce the PICS proforma in this subclause so that it can be used for its intended purpose and may further publish the completed PICS.

128.10.3 Major capabilities/options

Item	Feature	Subclause	Value/Comment	Status	Support
XGMII	XGMII	128.1, 46	Interface is supported	O	Yes [ ] No [ ]
PCS	Support of 2.5GBASE-X PCS/PMA	128.1		M	Yes [ ] ~~No [ ]~~
AN	Auto-Negotiation for Backplane Ethernet	128.1, 73	Device implements Auto-Negotiation for Backplane Ethernet	M	Yes [ ]
PSC	PSC associated with PMD supports AN service primitive AN_LINK	128.3	required generation of PMD primitive	M	Yes [ ]
DC	Delay Constraints	128.4	Device conforms to delay constraints	M	Yes [ ]
*MD	MDIO Capability	128.5	Registers and interface supported	O	Yes [ ] No [ ]
LPI	LPI	128.6.10	Capable of LPI	O	Yes [ ] No [ ]
*MD	MDIO interface	128.5	Device implements MDIO	O	Yes [ ] No [ ]
*SD	Signal Detect Generation	128.6.4	Signal detect implemented	O	Yes [ ] No [ ]
*TD	PMD_transmit_disable	128.6.5	Function is supported	EEE:M	Yes [ ] N/A~~No~~ [ ]

128.10.4 PICS proforma tables for Clause 128, Physical Medium Dependent (PMD) sublayer and baseband medium, type 2.5GBASE-KX.

128.10.4.1 PMD functional specifications

Item	Feature	Subclause	Value/Comment	Status	Support
FS1	PMD_global_signal_detect set to the value of SIGNAL_DETECT	128.2.3.2	required generation of PMD primitive	M	Yes [ ]
FS2	Tx+Rx delays from 2.5GBASE-KX PMD and medium ~~<=~~≤ 256 bit times	128.2.4	required timing	M	Yes [ ]
FS3	Transmit function	128.6.2	Conveys bits from PMD service interface to MDI	M	Yes [ ]
FS4	Transmitter signal	128.6.2	A positive differential voltage corresponds to tx_bit = ONE	M	Yes [ ]
FS5	Receive function	128.6.3	Conveys bits from MDI to PMD service interface	M	Yes [ ]
FS6	Receiver signal	128.6.3	A positive differential voltage corresponds to rx_bit = ONE	M	Yes [ ]
FS7	PMD Receive function	128.6.3	Convey the bits received at the MDI	M	Yes [ ]
FS8	PMD Signal Detect function	128.6.4	Continuously reported OK via PMD_SIGNAL.indication (SIGNAL_DETECT).	!SD:M	Yes [ ] N/A [ ]
FS9	PMD Signal Detect during LPI	128.6.4	Indicate signal energy during LPI	LPI:M	Yes [ ] N/A [ ]
FS10	Signal Detect for EEE	128.6.4	Transition timing to set SIGNAL_DETECT	LPI:M	Yes[ ] N/A [ ]
FS11	Report to PMD service I/O using PMD_SIGNAL indication	128.6.4	PMD signal detect behavior	LPI:M	Yes [ ] N/A [ ]
FS12	Transmit Disable	128.6.5	Disables Transmitter when PMD_Transmit_disable set to ONE	TD:M	Yes [ ] N/A [ ]
FS13	Transmit Disable during LPI	128.6.5	Disable transmitter during tx_quiet	LPI:M	Yes [ ] N/A [ ]
FS14	PMD_fault	128.6.5	Transmit disabled if detected	TD:O	Yes [ ] No [ ] N/A [ ]
FS15	PMD_transmit_disable	128.6.5	Loopback function not effected	TD:M	Yes [ ] N/A [ ]
FS16	tx_quiet disabled transmitter	128.7.1	Disables Transmitter when tx_quiet is asserted as specified in 128.7.1.5	LPI:M	Yes [ ] N/A [ ]
FS17	Loopback Function	128.6.6	Loopback function provided	M	Yes [ ]
FS18	Loopback ~~affect~~effect on Transmitter	128.6.6	Loopback function does not disable transmitter	M	Yes [ ]

128.10.4.2 Management functions

Item	Feature	Subclause	Value/Comment	Status	Support
MF1	MDIO Variable Mapping	128.5	Per Table 128–2 and Table 128–3	MD:M	Yes [ ] N/A [ ]
MF2	PMD_fault function	128.6.7	Sets PMD_fault to a logical 1 if any local fault is detected; otherwise, set to 0	MD:M	Yes [ ] N/A [ ]
MF3	PMD_transmit_fault function	128.6.8	Sets PMD_transmit_fault to a logical 1 if any local fault is detected on the transmit path; otherwise, set to 0	MD:M	Yes [ ] N/A [ ]
MF4	PMD_receive_fault function	128.6.9	Sets PMD_receive_fault to a logical 1 if any local fault is detected on the receive path; otherwise, set to 0	MD:M	Yes [ ] N/A [ ]

128.10.4.3 Transmitter electrical characteristics

Item	Feature	Subclause	Value/Comment	Status	Support
TC1	100 Ω differential test fixture	128.7.1.2	With return loss meeting Equation (128–1) and Equation (128–2)	M	Yes [ ]
TC2	Signaling speed	128.7.1.3	~~1.25~~ GBd ± 100ppm	M	Yes [ ]
TC3	Tx differential output voltage maximum	128.7.1.4	~~<~~1200 mV, pk-pk, with '1010' pattern	M	Yes [ ]
TC4	Tx differential output voltage~~-~~ maximum when disabled	128.7.1.4	~~<~~ 30 mV, pk-pk	M	Yes [ ]
TC5	Tx differential output voltage test pattern	128.7.1.4	no fewer than 8 symbols of alternating polarity '11111111 00000000'	M	Yes [ ]
TC6	Common-mode output voltage	128.7.1.4	Between ~~0.2~~ V and 1.9 V	M	Yes [ ]
TC7	Output Return Loss	128.7.1.6	Per Equation (128–3) and Equation (128–4)	M	Yes [ ]
TC8	Reference Impedance	128.7.1.6	100 Ω for differential return loss measurements	M	Yes [ ]
TC9	Transmit jitter, peak-to-peak	128.7.1.8	Max TJ of ~~0.25~~ UI. Max DJ of ~~0.10~~ UI	M	Yes [ ]
TC10	Output Amplitude LPI voltage	128.7.1.4	Less than 30 mV within 500 ns of tx_mode = QUIET	LPI:M	Yes [ ] N/A [ ]
TC11	Output Amplitude ON voltage	128.7.1.4	Greater than 720 mV within 500 ns of tx_mode = ALERT	LPI:M	Yes [ ] N/A [ ]
TC12	Output to DATA compliance timing	128.7.1.4	Fully compliant ~~<=~~≤ 5 sec from tx_mode = DATA	LPI:M	Yes [ ] N/A [ ]
TC13	Common mode voltage in LPI mode	128.7.1.4	output = ~~+/-~~± 150 mV of the pre-LPI value	LPI:M	Yes [ ] N/A [ ]
TC14	Differential Return Loss	128.7.1.5	Equation (128–3) and Equation (128–3) at reference impedance of 100 Ω	M	Yes [ ]
TC15	TX common mode return loss	128.7.1.6	Equation (128–3)	M	Yes [ ]
TC16	TX rise time and fall time	128.7.1.7	30 ps to 100 ps, 20%/80% of peak-to-peak differential with pattern in ~~128B.1~~	M	Yes [ ]
TC17	Jitter test patterns	128.7.1.8	Jitter test frame per 52.9.1.1	M	Yes [ ]
TC18	DCD test pattern	128.7.1.8	no fewer than 8 symbols of alternating polarity '11111111 00000000'	M	Yes [ ]
TC19	TX jitter limit	128.7.1.9	~~<=~~≤ 0.35 UI, peak-to-peak	M	Yes [ ]
TC20	TX DCD limit	128.7.1.9	~~<=~~≤ 0.035 UI, peak-to-peak	M	Yes [ ]
TC21	Tx output waveform measurement	128.7.1.10	Measured as shown in Figure 128–6	M	Yes [ ]

128.10.4.4 Receiver electrical characteristics

Item	Feature	Subclause	Value/Comment	Status	Support
RC1	Receiver interference tolerance measurement method	128.7.2.1	Per Annex ~~128B~~ with parameters specified in Table 128–6	M	Yes [ ]
RC2	Receiver interference tolerance test pattern	128.7.2.1	test patterns 2 or 3 as defined in 59.9.1.1	M	Yes [ ]
RC3	Receiver interference tolerance requirements	128.7.2.1	Satisfy requirements per Annex ~~128B~~	M	Yes [ ]
RC4	Input signaling speed in the range of 3.125 GBd ± 100ppm	128.7.2.2	Receiver meets requirements of Table 128–5	M	Yes [ ]
RC5	Receiver AC-coupled	128.7.2.3		M	Yes [ ]
RC6	Input signal amplitude	128.7.2.4	BER still met when compliant transmitter is connected with no attenuation	M	Yes [ ]
RC7	Differential input return loss	128.7.2.5	Per Equation (128–3) and Equation (128–4)	M	Yes [ ]
RC8	Reference Impedance	128.7.2.5	100 Ω for differential return loss measurements	M	Yes [ ]

128.10.4.5 Environmental and safety specifications

Item	Feature	Subclause	Value/Comment	Status	Support
ES1	General safety	128.9.1	Conforms to IEC 60950-1	M	Yes [ ]
ES2	Electromagnetic compatibility	128.9.4	Comply with applicable local and national codes	M	Yes [ ]

130. Physical Medium Dependent sublayer and baseband medium, type 5GBASE-KR

130.1 Overview

This clause specifies the 5GBASE-KR PMD and the baseband medium. When forming a complete PHY, a PMD shall be connected to the appropriate sublayers (see Table 130–1), and with the management functions that are optionally accessible through the management interface defined in Clause 45~~Clause 45~~, or equivalent.

Table 130–1—Physical Layer clauses associated with the 5GBASE-KR PMD

Associated clause	10GBASE-KR
46—XGMII[a]	Optional
73—Auto-Negotiation for Backplane Ethernet	Required
78—Energy-Efficient Ethernet	Optional
129—5GBASE-KR PCS/PMA	Required

[a]The XGMII is an optional interface. However, if the XGMII is not implemented, a conforming implementation must behave functionally as though the RS and XGMII were present.

A 5GBASE-KR PHY with the optional Energy-Efficient Ethernet (EEE) capability may optionally enter the Low Power Idle (LPI) mode to conserve energy during periods of low link utilization. The “Assert LPI” request at the XGMII is encoded in the transmitted symbols. Detection of LPI signaling in the received symbols is indicated as “Assert LPI” at the XGMII. Upon the detection of “Assert LPI” at the XGMII, an energy-efficient 5GBASE-KR PHY continues transmitting for a predefined period, then ceases transmission and deactivates transmit functions to conserve energy. The PHY periodically transmits during this quiet period to allow the remote PHY to refresh its receiver state (e.g., timing recovery, adaptive filter coefficients) and thereby track long-term variations in the timing of the link or the underlying channel characteristics. If, during the quiet or refresh periods, normal interframes resume at the XGMII, the PHY reactivates transmit functions and initiates transmission. This transmission will be detected by the remote PHY, causing it to also exit the LPI mode.

130.2 Physical Medium Dependent (PMD) service interface

The following specifies the services provided by the 5GBASE-R PMDs. These PMD sublayer service interfaces are described in an abstract manner and do not imply any particular implementation.

The PMD Service Interface supports the exchange of encoded and scrambled 64B/66B blocks between the PMA and PMD entities. The PMD translates the serialized data of the PMA to and from signals suitable for the specified medium.

The following primitives are defined:

PMD_UNITDATA.request(tx_bit)

PMD_UNITDATA.indication(rx_bit)
PMD_SIGNAL.indication(SIGNAL_DETECT)

If EEE is supported, the following primitives are also defined on the PMD Service Interface:

PMD_RX_MODE.request(rx_mode)
PMD_TX_MODE.request(tx_mode)

These messages affect the PCS variables as described in 49.2.13.2.2.

130.2.1 PMD_UNITDATA.request

This primitive defines the transfer of a serial data stream from the PMA to the PMD.

130.2.1.1 Semantics of the service primitive

PMD_UNITDATA.request(tx_bit)

The data conveyed by PMD_UNITDATA.request is a continuous stream of bits. The tx_bit parameter can take one of two values: ONE or ZERO.

130.2.1.2 When generated

The PMA continuously sends the appropriate stream of bits to the PMD for transmission on the medium, at ~~a nominal 5.15625 GBd~~ signaling speed for 5GBASE-R PMD types.

130.2.1.3 Effect of receipt

Upon receipt of this primitive, the PMD converts the specified stream of bits into the appropriate signals on the MDI.

130.2.2 PMD_UNITDATA.indication

This primitive defines the transfer of data (in the form of serialized data) from the PMD to the PMA.

130.2.2.1 Semantics of the service primitive

PMD_UNITDATA.indication(rx_bit)

The data conveyed by PMD_UNITDATA.indication is a continuous stream of bits. The rx_bit parameter can take one of two values: ONE or ZERO.

130.2.2.2 When generated

The PMD continuously sends stream of bits to the PMA corresponding to the signals received from the MDI.

130.2.2.3 Effect of receipt

The effect of receipt of this primitive by the client is unspecified by the PMD sublayer.

130.2.3 PMD_SIGNAL.indication

This primitive is generated by the PMD to indicate the status of the signal being received from the MDI.

130.2.3.1 Semantics of the service primitive

PMD_SIGNAL.indication(SIGNAL_DETECT)

The SIGNAL_DETECT parameter can take on one of two values: OK or FAIL, indicating whether the PMD is detecting signal at the receiver (OK) or not (FAIL). When SIGNAL_DETECT = FAIL, PMD_UNITDATA.indication(rx_bit) is undefined.

NOTE– SIGNAL_DETECT = OK does not guarantee that PMD_UNITDATA.indication(rx_bit) is known good. It is possible for a poor quality link to provide sufficient signal for a SIGNAL_DETECT = OK indication and still not meet the ~~10~~$^{-12}$ BER objective.

130.2.3.2 When generated

The PMD generates this primitive to indicate a change in the value of SIGNAL_DETECT. If the MDIO interface is implemented, then PMD_global_signal_detect shall be continuously set to the value of SIGNAL_DETECT.

130.2.3.3 Effect of receipt

The effect of receipt of this primitive by the client is unspecified by the PMD sublayer.

130.2.4 PMD_RX_MODE.request

This primitive is generated by the PCS Receive Process when EEE is supported to indicate that the input signal is quiet and the PMA and PMD receiver may go into a low power mode. When EEE is not supported, the primitive is never invoked and the PMD behaves as if rx_mode = DATA.

130.2.4.1 Semantics of the service primitive

PMD_RX_MODE.request(rx_mode)

The rx_mode parameter takes on one of two values: QUIET or DATA.

130.2.4.2 When generated

The PCS generates this primitive to request the appropriate PMD receive LPI state.

130.2.4.3 Effect of receipt

When rx_mode is QUIET, the PMD receive function may deactivate functional blocks to conserve energy. When rx_mode is DATA, the PMD receive function operates normally.

130.2.5 PMD_TX_MODE.request

This primitive is generated by the PCS Transmit Process when EEE is supported to indicate that the PMA and PMD transmit functions may go into a low power mode and to disable the PMD transmitter. See subclause 130.6.5. When EEE is not supported, the primitive is never invoked and the PMD behaves as if tx_mode = DATA.

130.2.5.1 Semantics of the service primitive

PMD_TX_MODE.request(tx_mode)

The tx_mode parameter takes on one of three values: QUIET, ALERT, or DATA.

130.2.5.2 When generated

The PCS generates this primitive to request appropriate PMD transmit LPI state.

130.2.5.3 Effect of receipt

When tx_mode is QUIET, the PMD Transmit function may deactivate functional blocks to conserve energy. When tx_mode is ALERT, the PMD Transmit function transmits the alert pattern. And when it is DATA, the PMD Transmit function operates normally.

130.3 PCS requirements for Auto-Negotiation (AN) service interface

The PCS associated with this PMD shall support the AN service interface primitive AN_LINK.indication defined in 73.9.

130.4 Delay constraints

Predictable operation of the MAC Control PAUSE operation (Clause 31, Annex 31B) demands that there be an upper bound on the propagation delays through the network. This implies that MAC, MAC Control sublayer, and PHY implementers must consider the delay maxima, and that network planners and administrators consider the delay constraints regarding concatenation of devices.

The sum of the transmit and the receive delays contributed by the 5GBASE-KR PMD and medium shall be no more than 1024 bit times. It is assumed that the round-trip delay through the medium is 80 bit times.

130.5 PMD MDIO function mapping

The optional MDIO capability described in Clause 45 defines several variables that provide control and status information for and about the PMD. If MDIO is implemented, it shall map MDIO control variables to PMD control variables as shown in Table 130–2, and MDIO status variables to PMD status variables as shown in Table 130–3.

Table 130–2—MDIO/PMD control variable mapping

MDIO control variable	PMA/PMD register name	Register/ bit number	PMD control variable
Reset	Control register 1	1.0.15	PMD_reset
Global PMD Transmit Disable	Transmit disable register	1.9.0	Global_PMD_transmit_disable

130.6 PMD functional specifications

130.6.1 Link block diagram

For purposes of system conformance, the PMD sublayer is standardized at test points TP1 and TP4 as shown in Figure 130–1. The transmitter and receiver blocks include all off-chip components associated with the

Table 130–3—MDIO/PMD status variable mapping

MDIO status variable	PMA/PMD register name	Register/ bit number	PMD status variable
Fault	Status register 1	1.1.7	PMD_fault
Transmit fault	Status register 2	1.8.11	PMD_transmit_fault
Receive fault	Status register 2	1.8.10	PMD_receive_fault
Global PMD Receive signal detect	Receive signal detect register	1.10.0	Global_PMD_signal_detect

respective block. For example, external AC-coupling capacitors, if required, are to be included in the receiver block.

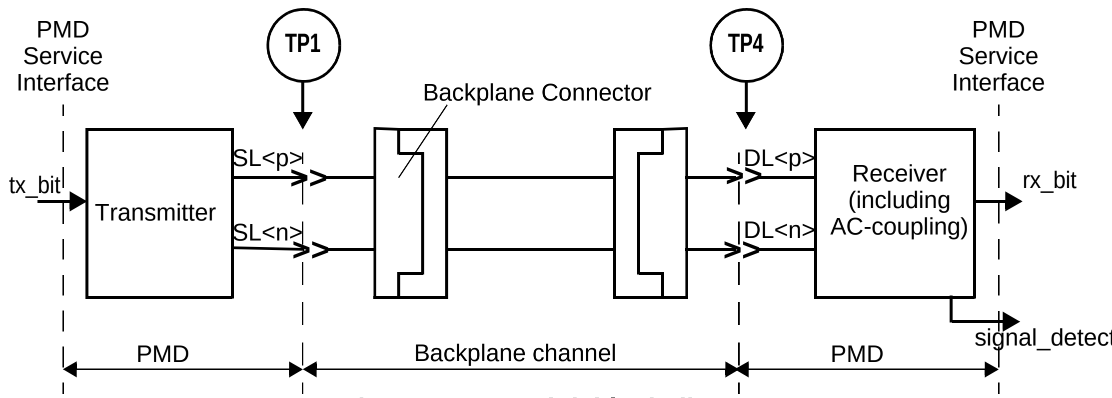

Figure 130–1—Link block diagram

The electrical path from the transmitter block to TP1, and from TP4 to the receiver block, will affect link performance and the measured values of electrical parameters used to verify conformance to this standard. Therefore, it is recommended that this path be carefully designed.

130.6.2 PMD transmit function

The PMD Transmit function shall convey the bits requested by the PMD service interface message PMD_UNITDATA.request(tx_bit) to the MDI according to the specifications in this clause. A positive output voltage of SL<p> minus SL<n> (differential voltage) shall correspond to tx_bit = ONE.

If the optional Energy-Efficient Ethernet (EEE) capability is supported (see Clause 78) then when tx_mode is set to ALERT, the PMD will transmit a repeating 16-bit pattern, hexadecimal 0xFF00.

130.6.3 PMD receive function

The PMD Receive function shall convey the bits received from the MDI according to the electrical specifications in this clause to the PMD service interface using the message PMD_UNITDATA.indication(rx_bit). A positive input voltage of DL<p> minus DL<n> (differential voltage) shall correspond to rx_bit = ONE.

130.6.4 PMD signal detect function

The Global_–PMD_–signal_–detect function reports to the PMD service interface, using the message PMD_SIGNAL.indication(SIGNAL_DETECT), which is signaled continuously. When the PMD signal detect function is implemented its definition is beyond the scope of this specification. When PMD signal detect is not implemented, the value of SIGNAL_DETECT shall be set to OK for purposes of management and signaling of the primitive. PMD signal detect is mandatory if EEE is supported. When the PHY supports the optional EEE capability, PMD_SIGNAL.indication is used to indicate when the ALERT signal is detected, which corresponds to the beginning of a refresh or a wake. If the MDIO interface is implemented, then Global_PMD_signal_detect (1.10.0) shall be continuously set to the value of SIGNAL_DETECT as described in 45.2.1.9.7.

When the PHY supports the EEE capability, SIGNAL_DETECT is set to FAIL following a transition from rx_mode = DATA to rx_mode = QUIET. When rx_mode = QUIET, SIGNAL_DETECT shall be set to OK within 500 ns following the application of a signal at the receiver input that is the output of a channel that satisfies the requirements of all the parameters of both interference tolerance test channels defined in 130.7.2.1 when driven by a square wave pattern with a period of 16 unit intervals and peak-to-peak differential output amplitude of 720 mV. While rx_mode = QUIET, SIGNAL_DETECT changes from FAIL to OK only after a valid ALERT signal is applied to the channel.

SIGNAL_DETECT shall be set to FAIL following system reset.

130.6.5 PMD transmit disable function

The Global_PMD_transmit_disable function is mandatory if EEE is supported and is otherwise optional. When this function is supported, it shall meet the requirements of this subclause.

a) When the Global_PMD_transmit_disable variable is set to ONE, this function shall turn off the transmitter such that it drives a constant level (i.e., no transitions) and does not exceed the maximum differential peak-to-peak output voltage specified in Table 130–4.
b) If a PMD_fault (130.6.7) is detected, then the PMD may turn off the electrical transmitter.
c) Loopback, as defined in 130.6.6, shall not be affectedeffected by Global_PMD_transmit_disable.
d) For EEE capability, the PMD_transmit_disable function shall turn off the transmitter after tx_mode is set to QUIET within a time and voltage level specified in 130.7.1.4. The PMD_transmit_disable function shall turn on the transmitter after tx_mode is set to DATA or ALERT within the time and voltage level specified in 130.7.1.4.

If the MDIO interface is implemented, then this function shall map to the Global_PMD_transmit_disable bit as specified in 45.2.1.8.7.

130.6.6 Loopback mode

Loopback mode shall be provided for the 5GBASE-KR PMD by the transmitter and receiver of a device as a test function to the device. When loopback mode is selected, transmission requests passed to the transmitter are shunted directly to the receiver, overriding any signal detected by the receiver on its attached link. This bit does not a the state of the transmitter. The method of implementing loopback mode is not defined by this standard.

Control of the loopback function is specified in 45.2.1.1.5.

NOTE 1—The signal path that is exercised in the loopback mode is implementation specific, but it is recommended that this signal path encompass as much of the circuitry as is practical. The intention of providing this loopback mode of operation is to permit diagnostic or self-test functions to test the transmit and receive data paths using actual data. Other loopback signal paths may also be enabled independently using loopback controls within other devices or sublayers.

NOTE 2—Placing a network port into loopback mode can be disruptive to a network.

130.6.7 PMD_fault function

If the MDIO is implemented, PMD_fault is the logical OR of PMD_receive_fault, PMD_transmit_fault, and any other implementation specific fault.

130.6.8 PMD transmit fault function

The PMD_transmit_fault function is optional. The faults detected by this function are implementation specific, but should not include the assertion of the Global_PMD_transmit_disable function.

If a PMD_transmit_fault (optional) is detected, then the Global_PMD_transmit_disable function should also be asserted.

If the MDIO interface is implemented, then this function shall be mapped to the PMD_transmit_fault bit as specified in 45.2.1.7.4.

130.6.9 PMD receive fault function

The PMD_receive_fault function is optional. The faults detected by this function are implementation specific.

If the MDIO interface is implemented, then this function shall contribute to PMA/PMD receive fault bit as specified in 45.2.1.7.5.

130.6.10 PMD LPI function

The PMD LPI function responds to the transitions between Active, Sleep, Quiet, Refresh, and Wake states via the PMD_TX_MODE and PMD_RX_MODE requests. Implementation of the function is optional. EEE capabilities and parameters will be advertised during the Backplane Auto-negotiation, as described in 45.2.7.14aa. The transmitter on the local device will inform the link partner’s receiver when to sleep, refresh and wake. The local receiver transitions are controlled by the link partner’s transmitter and can change independent of the local transmitter states and transitions.

130.7 5GBASE-KR electrical characteristics

130.7.1 Transmitter characteristics

Transmitter characteristics at TP1 are summarized in Table 130–4 and detailed in 130.7.1.1 through 130.7.1.11.

Table 130–4—Transmitter characteristics for 5GBASE-KR

Parameter	Subclause reference	Value	Units
Signaling speed	130.7.1.3	5.15625 ± 100 ppm	GBd
Differential peak-to-peak output voltage (max.)	130.7.1.4	1200	mV
Differential peak-to-peak output voltage (max.) with TX disabled	130.6.5	30	mV
Common-mode voltage limits	130.7.1.4	0 to 1.9	V
Common-mode voltage deviation (max) during LPI	130.7.1.4	150	mV
Differential output return loss (min.)	130.7.1.5	See Equation (130–4)	dB
Common-mode output return loss (min.)	130.7.1.6	See Equation (130–5)	dB
Transition time (20%–80%)	130.7.1.7	20 to 60	ps
Max output jitter (peak-to-peak) Random jitter[a] Deterministic jitter Duty Cycle Distortion[b] Total jitter	130.7.1.9	 0.15 0.12 0.035 0.30	 UI UI UI UI

[a]Jitter is specified at BER 10^{-12}.
[b]Duty Cycle Distortion is considered part of the deterministic jitter distribution.

130.7.1.1 Test fixture

The test fixture of Figure 130–2 or its functional equivalent, is required for measuring the transmitter specifications described in 130.7.1, with the exception of return loss.

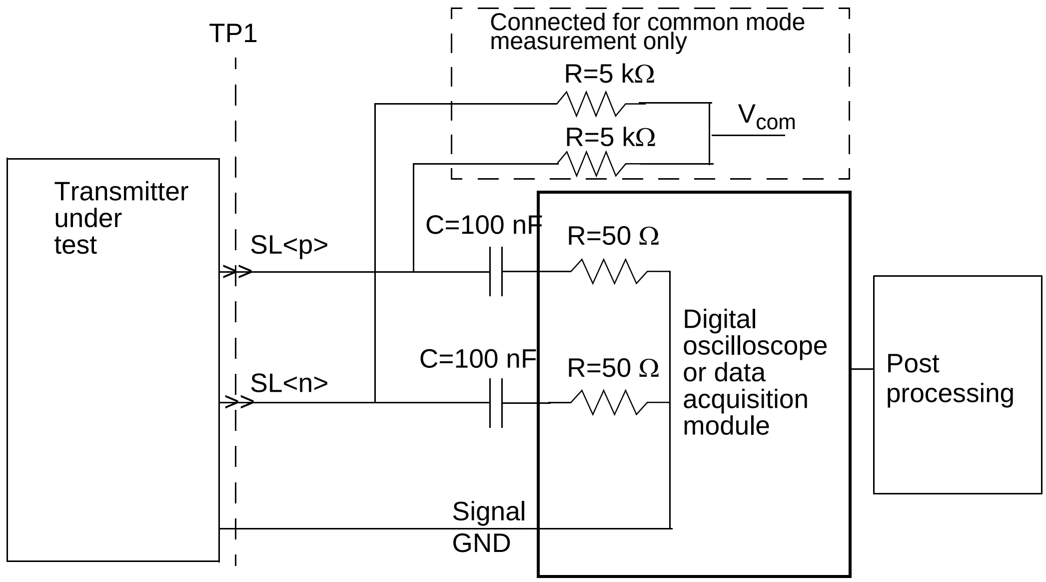

Figure 130–2—Transmit test fixture for 5GBASE-KR

130.7.1.2 Test fixture ~~impedance~~characteristics

The differential load impedance applied to the transmitter output by the test fixture depicted in Figure 130–2 shall be 100 Ω. The differential return loss, in dB with *f* in MHz, of the test fixture shall meet the requirements of Equation (130–1) and Equation (130–2).

$$Return\_Loss(f) \geq 20 \qquad (130\text{–}1)$$

for 100 MHz ≤ *f* < 2579 MHz

$$Return\_Loss(f) \geq 24 - 13.275\log_{10}\left(\frac{f}{1289\text{MHz}}\right) \qquad (130\text{–}2)$$

for 2579 MHz ≤ *f* ≤ 5156.25 MHz

130.7.1.3 Signaling speed

The 5GBASE-KR signaling speed shall be ~~5.15625 GBd ± 100 ppm~~.

130.7.1.4 Output amplitude

The differential output voltage is constrained via the transmitter output waveform requirements specified in 130.7.1.10. For a 1010 pattern, the peak-to-peak differential output voltage shall be ~~less than or equal to 1200 mV, regardless of equalization setting. The transmitter output voltage shall be less than~~ or equal to 30

~~mV peak-to-peak when disabled~~. The differential output voltage test pattern shall consist of no fewer than eight symbols of alternating polarity.

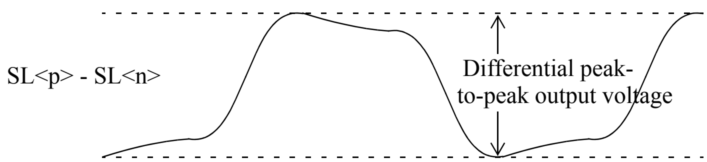

Figure 130–3—Transmitter differential peak-to-peak output voltage definition

NOTE—SL<p> and SL<n> are the positive and negative sides of the differential signal pair.

NOTE– See Figure 130–3 for an illustration of the definition of differential peak-to-peak output voltage. DC-referenced voltage levels are not defined since the receiver is AC-coupled. The common-mode voltage of SL<p> and SL<n> shall be between 0 V and 1.9 V with respect to signal ground as measured at V_{com} in Figure 130–2.

For EEE capability, the transmitter~~'s differential peak-to-peak output voltage shall be less than~~ or equal to 30 ~~mV~~ within 500 ns of tx_mode being set to QUIET and remain so while tx_mode is set to QUIET. Furthermore, the transmitter's differential peak-to-peak output voltage shall be greater than 720 mV within 500 ns of tx_mode being set to ALERT. The transmitter output shall be fully compliant within 5 µs after tx_mode is set to DATA. During LPI mode, the common-mode shall ~~be maintained to within ± 150 mV of~~ the pre-LPI value.

130.7.1.5 Differential output return loss

For frequencies from 100 MHz to 3750 MHz, the differential return loss, in dB with f in MHz, of the transmitter shall meet the requirements of ~~Equation (130–3) and Equation (130–4)~~. This output impedance requirement applies to all valid output levels. The reference impedance for differential return loss measurements shall be 100 Ω.

$$Return\_loss \geq 10 \qquad (130\text{–}3)$$

for 100 MHz ≤ f < 1289 MHz and,

$$Return\_loss(f) \geq 10 - 13.275\log_{10}\left(\frac{f}{1289}\right) \qquad (130\text{–}4)$$

for 1289 MHz ≤ f ≤ 3750 MHz.

The minimum differential output return loss is shown in Figure 130–4.

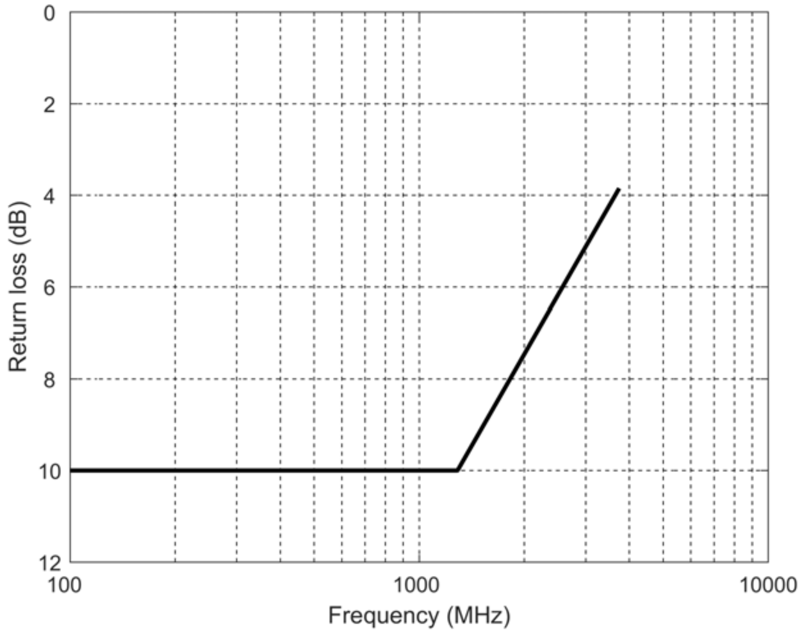

Figure 130–4—Transmit output differential mode return loss

130.7.1.6 Common-mode output return loss

The transmitter common-mode return loss shall meet the requirements of ~~Equation (130–5) and Equation (130–6)~~. The reference impedance for common-mode return loss measurements is 25 Ω.

$$Return\_loss \geq 7 \qquad (130\text{–}5)$$

for 100 MHz ≤ f < 1250 MHz,

$$Return\_loss(f) \geq 7 - 13.275\log_{10}\left(\frac{f}{1250\text{MHz}}\right) \qquad (130\text{–}6)$$

for 1250 MHz ≤ f ≤ 3750 MHz.

The minimum common-mode output return loss is shown in Figure 130–5.

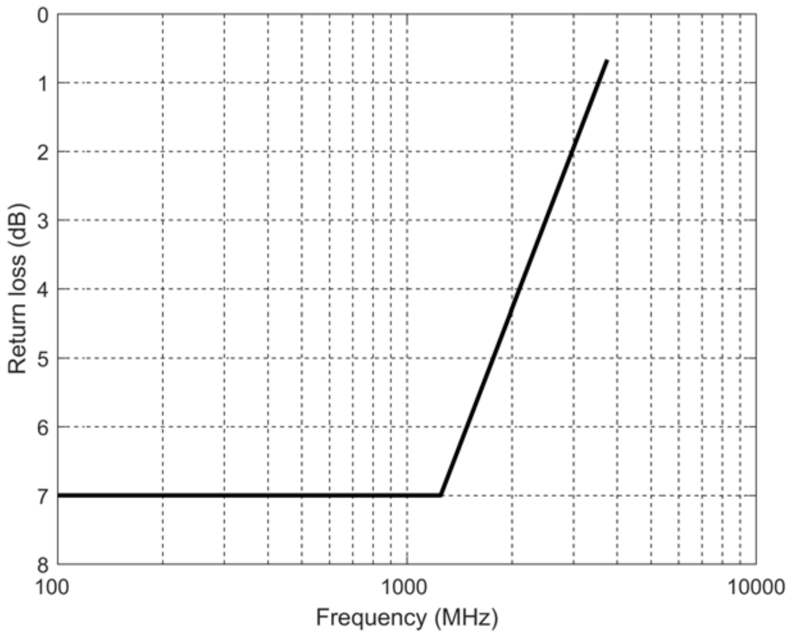

Figure 130–5—Transmit common-mode output return loss

130.7.1.7 Transition time

The rising and falling edge transition times shall be ~~between 20 ps and 60 ps as measured at the 20% and 80% levels referenced to~~ v_1 and v_3~~$_4$~~ as defined in 130.7.1.11. Measurement is done using the square wave test pattern defined in 52.9.1.2, with no equalization and a run of at least eight consecutive ones. ~~Transmit equalization may be disabled completely during this testing.~~

130.7.1.8 Transmit jitter test requirements

Transmit jitter is defined with respect to a test procedure resulting in a BER bathtub curve such as that described in Annex 48B.3. For the purpose of jitter measurement, the effect of a single-pole high-pass filter with a 3 dB point at 4 MHz is applied to the jitter. The data pattern for jitter measurements shall be test patterns 2 or 3 as defined in 52.9.1.1. Crossing times are defined with respect to the mid-point (0 V) of the AC-coupled differential signal. Equalization shall be off during jitter testing.

The duty cycle distortion test pattern shall consist of no fewer than eight symbols of alternating polarity.

130.7.1.9 Transmit jitter

The transmitter ~~shall have a maximum total jitter of 0.30 UI peak-to-peak, composed of a maximum deterministic component of 0.12 UI peak-to-peak and a maximum random component of 0.15 UI peak-to-peak.~~ Duty cycle distortion (DCD) is considered a component of deterministic jitter ~~and shall not exceed 0.035 UI peak-to-peak.~~ The peak-to-peak duty cycle distortion is defined as the absolute value of the difference in the mean pulse width of a 1 pulse or the mean pulse width of a 0 pulse (as measured at the mean of the high- and low-voltage levels in a clock-like repeating 0101 bit sequence) and the nominal pulse width. Jitter specifications are specified for BER 10^{-12}. Transmit jitter test requirements are specified in 130.7.1.8.

NOTE– Duty Cyle Distortion is also referred to as Even-odd jitter (see 92.8.3.8.1).

130.7.1.10 Transmitter output waveform

The 5GBASE-KR transmitter includes pre-emphasis to compensate for frequency-dependent loss in the backplane channel and facilitate data recovery at the receiver. This equalization may be accomplished with a two-tap finite impulse response (FIR) structure as shown in Figure 130–6.

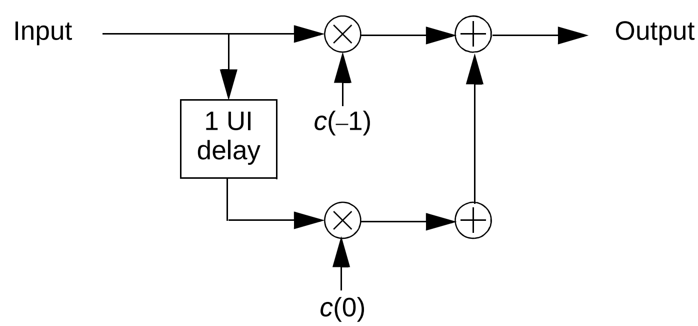

Figure 130–6—Transmit equalizer example

130.7.1.11 Transmitter output waveform requirements

The test pattern for the transmitter output waveform is the square wave test pattern defined in 52.9.1.2, with a run of at least eight consecutive ones. The transmitter output waveform test is based on the voltages v_1 through v_4, which shall be measured as shown in Figure 130–7 and described below.

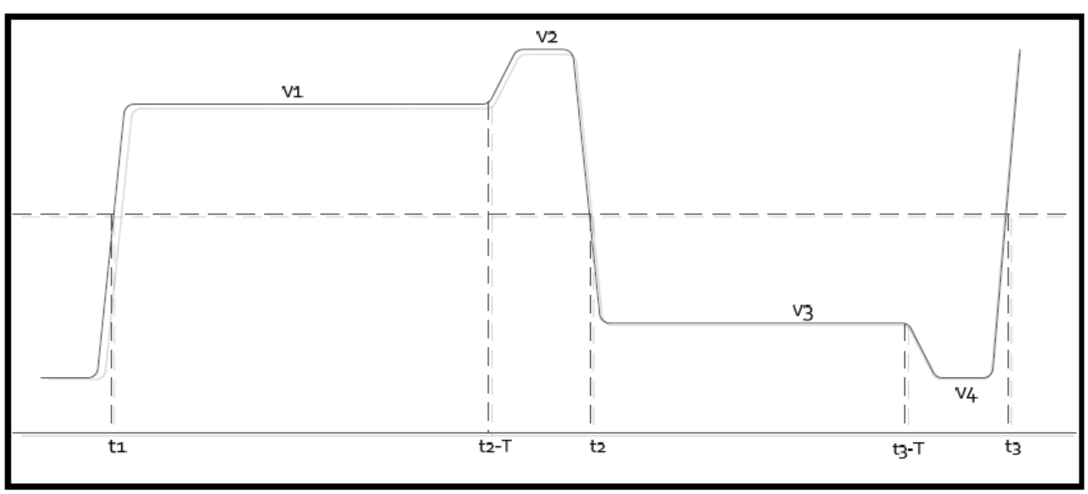

Figure 130–7—Transmitter output waveform

T	=	symbol period
t_1	=	zero-crossing point of the first rising edge of the AC-coupled signal
t_2	=	zero-crossing point of the falling edge of the AC-coupled signal
t_3	=	zero-crossing point of the second rising edge of the AC-coupled signal
v_1	=	positive steady-state voltage measured as the average voltage in the interval

t_1 + 2T to t_2 – 2T

v_2 = maximum voltage measured in the interval t_2 – T to t_2

v_3 = negative steady-state voltage measured as the average voltage in the interval t_2 + 2T to t_3 – 2T

v_4 = minimum voltage measured in the interval t3-T and t3

From these voltages, the pre-equalization ratios R_{pre} is derived from Equation (130–7).

$$R_{pre} = \frac{v_2}{v_1} \qquad (130–7)$$

130.7.2 Receiver characteristics

Receiver characteristics at TP4 are summarized in Table 130–5 and detailed in 130.7.2.1 through 130.7.2.5.

Table 130–5—Receiver characteristics for 5GBASE-KR

Parameter	Subclause reference	Value	Units
Bit error ratio	130.7.2.1	10^{-12}	
Signaling speed	130.7.2.2	5.15625 ± 100 ppm	GBd
Receiver coupling	130.7.2.3	AC	
Differential input peak-to-peak amplitude (max)	130.7.2.4	1200[a]	mV
Differential input return loss (min)[b]	130.7.2.5	Equation (130–4)	dB

[a]The receiver shall tolerate input amplitudes up to a maximum of 1600 mV without permanent damage.
[b]Relative to 100 Ω differential.

130.7.2.1 Receiver interference tolerance

The receiver interference tolerance consist of two separate tests as described in Annex ~~130B~~ with the parameters specified in Table 130–6. The data pattern for the interference tolerance test shall be the test patterns 2 or 3 as defined in 52.9.1.1. The receiver shall satisfy the requirements for interference tolerance specified in Annex ~~130B~~ for both tests.

Table 130–6—5GBASE-KR interference tolerance parameters

Parameter	Test 1 values	Test 2 values	Units
Target BER	10^{-12}	10^{-12}	
m_{TC} (min.)[a]	1.0	0.5	
Amplitude of broadband noise (min. RMS)	10.2	16	mV
Applied transition time (20%–80%, min.)	60	60	ps
Applied Sinusoidal jitter (min. peak-to-peak)	0.12	0.12	UI
Applied random jitter (min. peak-to-peak)[b]	0.12	0.12	UI
Applied Duty Cycle Distortion (min. peak-to-peak)	0.035	0.035	UI

[a] m_{TC} is defined in Equation ~~(130B–5)in~~ Annex ~~130B.~~
[b] Applied random jitter is specified at a BER of 10^{-12}.

130.7.2.2 Signaling speed range

~~A~~ 5GBASE-KR receiver shall comply with the requirements of Table 130–5 ~~for any signaling speed in the range 5.15625 GBd ± 100 ppm~~.

130.7.2.3 AC-coupling

The 5GBASE-KR receiver shall be AC-coupled to the backplane to allow for maximum interoperability between various 5 Gb/s components. AC-coupling is considered to be part of the receiver for the purposes of this specification unless explicitly stated otherwise. There may be various methods for AC-coupling in actual implementations.

NOTE—It is recommended that the maximum value of the coupling capacitors be limited to 100 nF. This will limit the inrush currents to the receiver that could damage the receiver circuits when repeatedly connected to transmit modules with a higher voltage level.

130.7.2.4 Input signal amplitude

5GBASE-KR receivers shall accept differential input signal peak-to-peak amplitudes produced by compliant transmitters connected without attenuation to the receiver, and still meet the BER requirement specified in 130.7.2.1. This may be larger than the ~~1200 mV~~ differential maximum of 130.7.1.4 due to the actual transmitter output and receiver input impedances. The input impedance of a receiver can cause the minimum signal into a receiver to differ from that measured when the receiver is replaced with a 100 Ω test load. Since the channel is AC-coupled, the absolute voltage levels with respect to the receiver ground are dependent on the receiver implementation.

130.7.2.5 Differential input return loss

For frequencies from 100 MHz to 3750 MHz, the differential return loss, in dB with f in MHz, of the receiver shall be ~~greater than or equal to Equation (130–3) and Equation (130–4)~~. This return loss requirement applies at all valid input levels. ~~The reference impedance for differential return loss measurements is 100 Ω.~~

130.8 Interconnect characteristics

Informative interconnect characteristics are provided in ~~Annex 130B~~Annex 128C.

130.9 Environmental specifications

130.9.1 General safety

All equipment that meets the requirements of this standard shall conform to applicable sections (including isolation requirements) of IEC 60950-1.

130.9.2 Network safety

The designer is urged to consult the relevant local, national, and international safety regulations to ensure compliance with the appropriate requirements.

130.9.3 Installation and maintenance guidelines

It is recommended that sound installation practice, as defined by applicable local codes and regulations, be followed in every instance in which such practice is applicable.

130.9.4 Electromagnetic compatibility

A system integrating the 5GBASE-KR PHY shall comply with applicable local and national codes for the limitation of electromagnetic interference.

130.9.5 Temperature and humidity

A system integrating the 5GBASE-KR PHY is expected to operate over a reasonable range of environmental conditions related to temperature, humidity, and physical handling (such as shock and vibration). Specific requirements and values for these parameters are considered to be beyond the scope of this standard.

130.10 Protocol implementation conformance statement (PICS) proforma for Clause 130, Physical Medium Dependent (PMD) sublayer and baseband medium, type 5GBASE-KR[4]

130.10.1 Introduction

The supplier of a protocol implementation that is claimed to conform to IEEE Std 802.3, Clause 130, Physical Medium Dependent (PMD) sublayer and baseband medium type 5GBASE-KR, shall complete the following protocol implementation conformance statement (PICS) proforma. A detailed description of the symbols used in the PICS proforma, along with instructions for completing the PICS proforma, can be found in Clause 21.

130.10.2 Identification

130.10.2.1 Implementation identification

Supplier	
Contact point for inquiries about the PICS	
Implementation Name(s) and Version(s)	
Other information necessary for full identification—e.g., name(s) and version(s) for machines and/or operating systems; System Name(s)	
NOTE 1—Only the first three items are required for all implementations; other information may be completed as appropriate in meeting the requirements for the identification. NOTE 2—The terms Name and Version should be interpreted appropriately to correspond with a supplier's terminology (e.g., Type, Series, Model).	

130.10.2.2 Protocol summary

Identification of protocol standard	IEEE Std 802.3-20xx, Clause 130, Physical Medium Dependent (PMD) sublayer and baseband medium type 5GBASE-KR
Identification of amendments and corrigenda to this PICS proforma that have been completed as part of this PICS	
Have any Exception items been required? No [ ] Yes [ ] (See Clause 21; the answer Yes means that the implementation does not conform to IEEE Std 802.3-20xx.)	
Date of Statement	

[4]*Copyright release for PICS proformas:* Users of this standard may freely reproduce the PICS proforma in this subclause so that it can be used for its intended purpose and may further publish the completed PICS.

130.10.3 Major capabilities/options

Item	Feature	Subclause	Value/Comment	Status	Support
XGE	XGMII	130.1, 46	Interface is supported	O	Yes [ ] No [ ]
PCS	Support of 5GBASE-R PCS/PMA	130.1, 49		M	Yes [ ]
AN	Auto-Negotiation for Backplane Ethernet	130.1, 73	Device implements Auto-Negotiation for Backplane Ethernet	M	Yes [ ]
DC	Delay Constraints	130.4	Device conforms to delay constraints	M	Yes [ ]
LPI	LPI	130.6.10	LPI	O	Yes [ ] No [ ]
*MD	MDIO interface	130.5	Device implements MDIO	O	Yes [ ] No [ ]
*TD	Global_PMD_transmit_disable	130.6.5		O	Yes [ ] No [ ]

130.10.4 PICS proforma tables for Clause 130, Physical Medium Dependent (PMD) sublayer and baseband medium, type 10GBASE-KR

130.10.4.1 PCS requirements for AN service interface

Item	Feature	Subclause	Value/Comment	Status	Support
PR1	AN service interface primitive	130.3	The PCS associated with this PMD supports the primitive AN_LINK.indication defined in 73.9	M	Yes [ ]

130.10.4.2 PMD functional specifications

Item	Feature	Subclause	Value/Comment	Status	Support
FS1	PMD combined with sublayers through interface defined in Clause 45.	130.1	2.GBASE-KX PHY layer associations. See Table 130–1	M	Yes [ ]
FS2	PMD_global_signal_detect set to the value of SIGNAL_DETECT	130.2.3.2	Required generation of PMD primitive	M	Yes [ ]
FS3	Tx+Rx delays from 2.5GBASE-KX PMD and medium <=≤ 256 bit times	130.4		M	Yes [ ]
FS4	Transmit function	130.6.2	Conveys bits from PMD service interface to MDI	M	Yes [ ]
FS5	Transmitter signal	130.6.2	A positive differential voltage corresponds to tx_bit = ONE	M	Yes [ ]
FS6	Receive function	130.6.3	Conveys bits from MDI to PMD service interface	M	Yes [ ]
FS7	Receiver signal	130.6.3	A positive differential voltage corresponds to rx_bit = ONE	M	Yes [ ]
FS8	PMD_fault indicates local fault in MDIO implementation	130.6.3	As specified in Table 45.2.1.7.4	MD:M	Yes [ ] N/A [ ]
FS9	Signal detect	130.6.4	Report to PMD service interface	M	Yes [ ]
FS10	Global signal detect	130.6.4	Value described in 45.2.1.9.7	M	Yes [ ]
FS11	Global_PMD_signal_detect set to SIGNAL_DETECT	130.6.4	As described in Table 130–3	MD:M	Yes [ ] N/A [ ]
FS12	SIGNAL_DETECT value	130.6.4	Set to FAIL	M	Yes [ ]
FS13	Signal detect during LPI	130.6.4	Detect signal energy during LPI	LPI:M	Yes [ ] N/A[ ]
FS14	Signal detect for EEE	130.6.4	Transition timing to set SIGNAL_DETECT	LPI:M	Yes [ ] N/A [ ]
FS15	Transmit disable requirements	130.6.5	Requirements of 130.6.5 and Table 130–4	TD:M	Yes [ ] N/A[ ]
FS16	Loopback not affectedeffected by- Global_PMD_transmit_disable	130.6.5		M	Yes [ ] N/A[ ]
FS17	Transmit disable during LPI	130.6.5	Disable transmitter during tx_mode = QUIET	LPI:M	Yes [ ] N/A[ ]
FS18	Loopback support	130.6.6	Provided for 10GBASE-KR PMD by transmitter and receiver	M	Yes [ ]

130.10.4.3 Management functions

Item	Feature	Subclause	Value/Comment	Status	Support
MF1	MDIO Variable Mapping	130.5	Per Table 130–2 and Table 130–3	MD:M	Yes [ ] N/A [ ]
MF2	PMD_transmit_fault function	130.6.8	Sets PMD_transmit_fault as specified in 45.2.1.7.4	MD:M	Yes [ ] N/A [ ]
MF3	PMD_receive_fault function	130.6.9	Sets PMD_receive_fault as specified in 45.2.1.7.5	MD:M	Yes [ ] N/A [ ]

130.10.4.4 PMD Transmitter electrical characteristics

Item	Feature	Subclause	Value/Comment	Status	Support
TC1	Test fixture impedance	130.7.1.2	100 Ω	M	Yes [ ]
TC2	Differential return loss of test fixture	130.7.1.2	Per Equation (130–1) and Equation (130–2)	M	Yes [ ]
TC3	Signaling speed	130.7.1.3	5.15625 GBd ± 100 ppm	M	Yes [ ]
TC4	Maximum transmitter differential peak-to-peak voltage	130.7.1.4	~~Less than~~ 1200 mV for a 1010 pattern	M	Yes [ ]
TC5	Maximum transmitter differential peak-to-peak voltage when TX disabled	130.7.1.4	~~Less than~~ 30 mV	M	Yes [ ]
TC6	Tx differential output voltage test pattern	130.7.1.4	No fewer than 8 symbols of alternating polarity; '11111111 00000000'	M	Yes [ ]
TC7	Common-mode output voltage	130.7.1.4	Between ~~–0.2~~V and +1.9 V	M	Yes [ ]
TC8	Tx output to DATA compliance timing	130.7.1.4	fully compliant ≤ 5 sec from tx_mode = DATA	M	Yes [ ]
TC9	Output Amplitude LPI voltage	130.7.1.4	~~Less than~~ 30 mV within 500 ns of tx_quiet	LPI:M	Yes [ ] N/A [ ]
TC10	Output Amplitude ON voltage	130.7.1.4	> 720 mV within 500 ns of tx_quiet de-asserted	LPI:M	Yes [ ] N/A [ ]
TC11	Common mode maintained within voltage limits	130.7.1.4	output ~~=~~± 150 mV of the pre-LPI value	LPI:M	Yes [ ] N/A [ ]
TC12	Differential output return loss	130.7.1.5	Per Equation (130–3) and Equation (130–4)	M	Yes [ ]
TC13	Differential output reference impedance	130.7.1.5	100 Ω	M	Yes [ ]
TC14	Common-mode output return loss	130.7.1.6	Per Equation (130–5) and Equation (130–6)	M	Yes [ ]

Item	Feature	Subclause	Value/Comment	Status	Support
TC15	Rising edge transition time	130.7.1.7	Between ~~30~~ ps and ~~100~~ ps measured at the 20% and 80% of peak-to-peak differential with pattern in ~~128B.1~~	M	Yes [ ]
TC16	Falling edge transition time	130.7.1.7	Between ~~30~~ ps and ~~100~~ ps measured at the 20% and 80% of peak-to-peak differential with pattern in ~~128B.1~~	M	Yes [ ]
TC17	Transmit jitter, peak-to-peak	130.7.1.9	Max Tj of ~~0.30~~ UI	M	Yes [ ]
TC18	Duty Cycle Distortion	130.7.1.9	Not to exceed 0.035 UI	M	Yes [ ]
TC19	Jitter test patterns	130.7.1.8	Test patterns 2 or 3 as defined in 52.9.1.1	M	Yes [ ]
TC20	DCD test pattern	130.7.1.8	No fewer than 8 symbols of alternating polarity; '11111111 00000000'	M	Yes [ ]
TC21	*Tx output waveform measurement criteria:* v_1, v_2, v_3, v_4,	130.7.1.10 130.7.1.11	Measured as per Figure 130–7.	M	Yes [ ]

130.10.4.5 Receiver electrical characteristics

Item	Feature	Subclause	Value/Comment	Status	Support
RC1	Receiver amplitude tolerance	130.7.2	Amplitudes of ≤~~1200~~ mV without permanent damage	M	Yes [ ]
RC2	Receiver interference tolerance	130.7.2.1	Measured as described in Annex ~~130B~~ with parameters ~~in Table 130–5~~	M	Yes [ ]
RC3	Receiver interference tolerance	130.7.2.1	Test patterns 2 or 3 as defined in 59.9.1.1	M	Yes [ ]
RC4	Receiver interference tolerance	130.7.2.1	Satisfy the requirements specified in ~~Annex 130B~~	M	Yes [ ]
RC5	Signaling speed	130.7.2.2	5.15625 GBd ±100 ppm	M	Yes [ ]
RC6	Receiver coupling	130.7.2.3	AC-coupled	M	Yes [ ]
RC7	Input signal amplitude	130.7.2.4	BER met when compliant transmitter is connected with no attenuation	M	Yes [ ]
RC8	Differential return loss	130.7.2.5	Per Equation (130–3) and Equation (130–4)	M	Yes [ ]
RC9	Differential return loss reference impedance	130.7.2.5	100 Ω	M	Yes [ ]

130.10.4.6 Environmental specifications

Item	Feature	Subclause	Value/Comment	Status	Support
ES1	General safety	130.9.1	Complies with applicable section of IEC 60950-1	M	Yes [ ]
ES2	Electromagnetic interference	130.9.4	Complies with applicable local and national codes	M	Yes [ ]