Digital Signal Detect Function

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Problem Statement

Robust analog signal detect functions are difficult to define and implement in the backplane Ethernet environment.

- Must reject noise signals
- Must detect all valid signals
- Little margin between noise and signals
- Margin may even be negative
  - e.g. if higher crosstalk is allowed on short links

Overly strict analog signal detect implementations have produced interoperability problems for predecessors.

Signal detect objectives

Allow link up when a link partner is present.

- **Achieve interoperability**

Prevent link up when the link is disconnected.

- **Primary purpose: keep a clean self-crosstalk or alien crosstalk signal from bringing the link up.**
- **Historically, needed to protect against spurious collisions in a CSMA/CD network.**
- **For full duplex, aids in management and trouble shooting.**
- **Also provides some emissions/power benefits by preventing full speed transmission to a disconnected link.**

Digital signal detect

- Use auto-negotiation algorithm to ensure there is a partner before starting.
- Systems that disable auto-negotiation should provide alternative protection
  - e.g. out-of-band blade presence detection
- All the PCS sublayers we use have mechanisms for qualifying signal quality in the digital domain.
  - Small changes could be made to strengthen the digital signal quality tests

This can replace a mandatory analog signal detect.

Signal detect due to crosstalk

A crosstalk signal that is coupled uniformly enough to look like a low power version of a received signal

Problem generally occurs due to:

- High receive amplification
- Localized crosstalk provides wide-band coupling across the signal band
  - for example, crosstalk at a connector or at the device edge.
- Stronger adaptive capability in the receiver (e.g. adaptive equalization) may enhance the effect by accommodating a wider range of coupling.

Using auto-negotiation to eliminate detection of crosstalk as receive signal

Even unaltered, DME provides a great deal of protection.

- bandwidth primarily from 75 MHz to 160 MHz
- crosstalk is less in this band
- very broadband crosstalk required to couple DME and operational signaling.
- to progress through auto-negotiation, perceived link partner must be going through auto-negotiation in reasonable step with local node.

Possible enhancements:

- reject DME from local node's transmitter
- ensure perceived link partner has received local node's DME pages.

Rejection of local transmitter's DME pages

Add a 5-bit nonce to DME base page

- Psuedo-random number
- Generate for each auto-negotiation attempt.

Compare received nonce to transmitted nonce.

If equal - may be seeing own transmitter - try again

If different - proceed with auto-negotiation.

Nonce check changes to Clause 73 Arbitration state diagram

Add nonce_match variable

change transition from ABILITY_DETECT to ACKOWLEDGE_DETECT to:

ability_match=true * nonce_match=false

add transition from ABILITY_DETECT to TRANSMIT_DISABLE on:

ability_match=true * nonce_match=true

Ensure link partner has received local node's DME page

Link partner inserts a copy of received nonce, ack_nonce, into the Acknowledge DME page.

When the acknowledge DME base page is received, compare received ack_nonce to transmitted nonce.

If different, the perceived link partner isn't your partner - try again.

If received ack_nonce equals transmitted nonce - proceed with auto-negotiation.

Ack_nonce changes to Clause 73 Arbitration state diagram

Add ack_nonce_match variable

In ACKNOWLEDGE_DETECT, insert rx_nonce into what is now R0 to R4

Exclude these bits from consistency_match.

change transition from ACKNOWLEDGE_DETECT to COMPLETE_ACKNOWLEDGE to:

acknowledge_match=true * consistency_match=true * ack_nonce_match=true

change transition from ACKNOWLEDGE_DETECT to TRANSMIT_DISABLE to:

(acknowledge_match=true * (consistency_match=false +ack_nonce_match=false) + an_receive_idle=true

Alternatives for nonce usage and location

Nonce length.

- 5 bits means a 3.1% chance of a random match with link partner, 0.1% of random match twice in a row.

Ack_nonce location

- Used location in first 16 bits of page to keep in same register as ACK bit
- Could move C bits to keep two reserved bits in the first 16.
- Use same location for original nonce and ack_nonce or keep original nonce in DME acknowledge page?

Ack_nonce test

- Seems a bit paranoid, but my sense of the room in March was that people wanted a very tight check - Do we need it?

Systems that disable Auto-negotiation

Add something like:

If auto-negotiation is disabled, the system should provide an out-of-band means for detecting link partner presence before enabling links.

Digital signal quality tests

- 1000BASE-KX and 10GBASE-KX4
  - state machines to detect synchronization to comma characters.
- 10GBASE-KX4
  - additionally requires alignment detection
- 10GBASE-KR
  - training process checks on received signal
  - detection of block lock and
  - BER monitor state machine

Recommendations

Make analog signal detect optional - see my review comments for execution

Add nonces and the related state machine tests to Auto-negotiation.

Add recommendation that systems which disable auto-negotiation provide alternative protection against false link up.

Given these steps, existing signal quality tests should be adequate.

Background

Slides from March 2005 on ways signal quality tests could be strengthened.

1000BASE-KX sync detect

- Sync detect requires
  - Detection of three commas aligned in the odd code groups
  - No intervening bad code groups (8B/10B code violation or improperly aligned commas)
- Loss of sync requires a count of 4 bad code groups.
  - Count up when a bad code group is received
  - Count down when 4 successive good code groups are received

Strengthening 1000BASE-KX sync detect

- Detection of sync
  - Increase the number of good commas that must be received before setting sync_status_KX = OK
- Loss of sync.
  - A short burst error should not cause loss of sync so leave the count at 4 for loss of sync
  - Increase the number of good code groups need to cause a count down.

10GBASE-KX sync detect and alignment

- Sync detection and loss
  - same as 1000BASE-KX on each of the 4 lanes
- Alignment detection
  - Sync has been acquired on all four lanes followed by
  - Detection of 4 sets of properly aligned A characters with no intervening deskew errors
- Loss of alignment requires a count of 4
  - A deskew error causes a count up
  - Properly aligned set of A characters causes a count down.

Strengthening 10GBASE-KX4 quality detect

- The existing tests are probably strong enough.

10GBASE-KR block lock

- Block lock detection requires
  - 64 valid sync headers with no intervening invalid sync headers
- Loss of block lock requires
  - Detection of 16 invalid sync headers within 64 blocks
- Detection of high BER (hi_ber) requires
  - Detection of 16 or more invalid sync headers within 125 us.

Strengthening 10GBASE-KR signal detect

- Current block lock and BER state machines may be strong enough
- If necessary we could
  - increase the number of valid sync headers that must be detected for block lock
  - decrease the number of bad sync headers for loss of block lock, or
  - decrease the number of bad sync headers for high BER or increase the duration of the test

Conclusion

Rely on digital signal quality measures for signal detect.

Remove mandatory analog signal detect requirements.

May still allow optional analog signal detect which must detect any valid signal as signal present.