IEEE P802.3cg
Comment #425 on subclause: 146.8.3 MDI return loss

David D. Brandt, Rockwell Automation
George Zimmerman, CME Consulting
Piergiorgio Beruto, Canova Tech

Purpose

- The purpose of this presentation is to:
  - Examine “MDI return loss”
  - Propose resolution to Comment #425

Comment #425, MDI return loss

- Comment to eliminate specific implementation

Cl **147** *SC* **147.9.2.1** *P* **152** *L* **9** # **425**

Zimmerman, George — CME Consulting et al

Comment Type **T** *Comment Status* **D** *MDI*

MDI return loss specifies the termination. Requiring the termination of the MDI would specify an implementation.

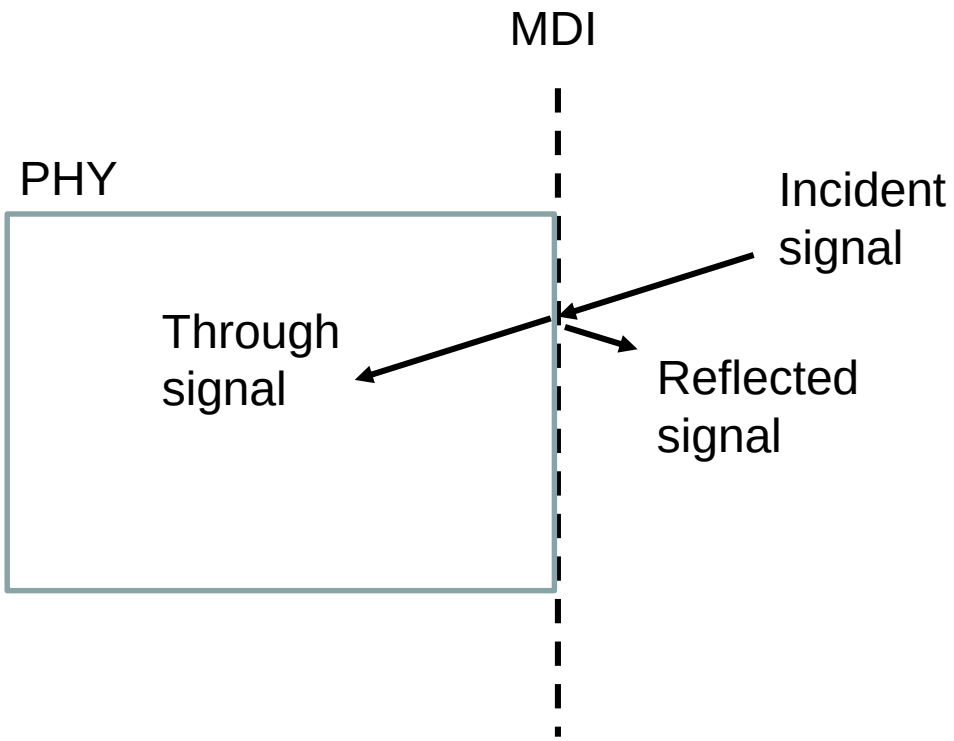
SuggestedRemedy

Change "In multidrop configuration the MDI shall be terminated by two 100 ? (nominal) impedances
satisfying Equation (147-6) when measured with 100 ? ±1% impedance at the edges." to "The MDI return loss (RL) shall meet or exceed Equation (147-6) for all frequencies specified (with 100 ? ± 0.1 % reference impedance) at all times when the PHY is transmitting data."

Proposed Response *Response Status* **W**

PROPOSED ACCEPT IN PRINCIPLE.
Change "In multidrop configuration the MDI shall be terminated by two 100 ? (nominal) impedances satisfying Equation (147-6) when measured with 100 CAP_OMEGA ±1% impedance at the edges." to "The MDI return loss (RL) shall meet or exceed Equation (147-6) for all frequencies specified (with 100 CAP_OMEGA ± 0.1 % reference impedance) at all times when the PHY is transmitting data."
Notes:
- CAP_OMEGA is capital omega
- spaces before CAP_OMEGA and ± are non-breaking

What is “MDI return loss”?



- Signal is incident upon MDI
- Some portion is reflected

$$RL(dB) = 20\log\left(\frac{Vi}{Vr}\right)$$

$$\Gamma = Vr/Vi$$

MDI return loss in 802.3

Examples

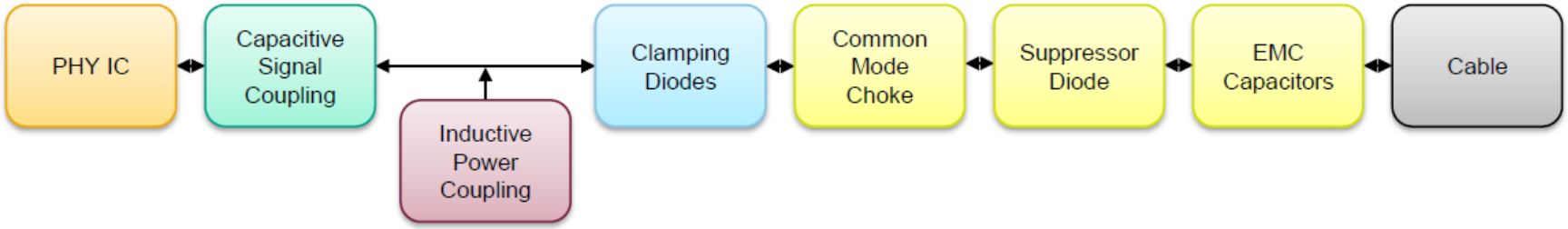
- IEEE 802.3bw-2015
- IEEE 802.3bp-2016
- IEEE 802.3-2015, 1000BASE-T
- IEEE 802.3-2015, 10GBASE-T
- IEEE 802.3-2015, 10BASE-T
- IEEE 802.3bu-2016

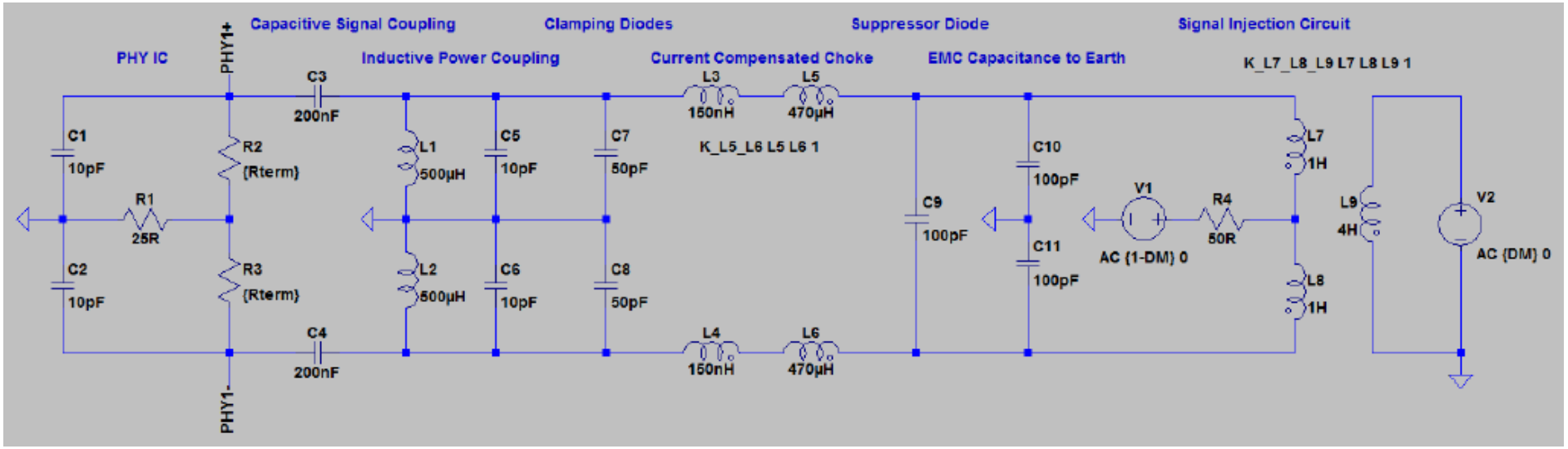
Characteristics

- All allow full duplex operations
- Focus is on limiting output and input impedance bounds (mismatch) for a PHY
- Output impedance is measured during transmission

What causes mismatch?

- http://www.ieee802.org/3/cg/public/July2017/Graber_3cg_11_0717.pdf





Why characterize mismatch by MDI return loss?

- When a source impedance and load impedance are matched, there is no reflection

- If they are mismatched, the source and load can be swapped and there is still a mismatch
  - Related mismatch can be measured from either side of an interface

$$\Gamma = \frac{Z_L - Z_S}{Z_L + Z_S}$$

- It is more practical (and implementation independent) to measure the mismatch from outside the PHY looking in

Why care about mismatch?

- Full duplex
  - Reflection at transmitter can interfere with the receive signal, adding to reflections from the media
- Half duplex
  - Reflection above the receive threshold may appear as a collision (self-collision)
    - Reflection can change phase
- Both
  - Transmit power is lost (at one or both ends)
  - Droop increases

Discussion

- Too little MDI return loss can impair the ability of otherwise compliant PHYs to communicate reliably over a compliant link segment or compliant mixing segment

- For the half duplex multidrop:
  - Transmit won't interfere with receive
  - Transmit PSD and receiver load are specified
  - The droop will be specified
  - A PHY with self-colliding transmission would be unreliable and should be fixed
    - Would not prevent interoperation of other nodes

- Do we really need MDI return loss for multidrop?

Proposal

- Eliminate 147.9.2.1 MDI Return loss

BACKUP

IEEE 802.3bw-2015

- 96.8.2.1 MDI return loss
  - The MDI return loss (RL) shall meet or exceed Equation (96–11) for all frequencies from 1 MHz to 66 MHz (with 100 Ω reference impedance) at all times **when the PHY is transmitting data or control symbols**.

IEEE 802.3bp-2016

- 97.7.2.1 MDI return loss
  - The differential impedance at the MDI (see Figure 97–43) for each transmit/receive channel shall be such that any reflection (due to differential signals incident upon the MDI with a test port having a differential impedance of 100 Ω is attenuated relative to the incident signal per Equation (97–29).

IEEE 802.3-2015, 1000BASE-T

- 40.8.3.1 MDI return loss
  - The differential impedance at the MDI for each transmit/receive channel shall be such that any reflection due to differential signals incident upon the MDI from a balanced cabling having an impedance of 100 Ω ± 15% is attenuated, relative to the incident signal, at least 16 dB over the frequency range of 1.0 MHz to 40 MHz and at least 10 – 20log10(f/80) dB over the frequency range 40 MHz to 100 MHz (f in MHz). This return loss shall be maintained at all times **when the PHY is transmitting data or control symbols**.

IEEE 802.3-2015, 10GBASE-T

- 55.8.2.1 MDI return loss
  - The differential impedance at the MDI for each transmit/receive channel shall be such that any reflection due to differential signals incident upon the MDI from a balanced cabling having a nominal differential characteristic impedance of 100 Ω is attenuated, relative to the incident signal as per the relationship:

IEEE 802.3-2015, 10BASE-T

- 14.3.1.2.2 Transmitter differential output impedance
  - The **differential output impedance as measured** on the TD circuit shall be such that **any reflection, due to differential signals incident upon the TD circuit from a simplex link segment having any impedance within the range specified in 14.4.2.2, shall be at least 15 dB below the incident**, over the frequency range of 5.0 MHz to 10 MHz. This return loss shall be maintained at all times when the MAU is powered, including when the TD circuit is sending TP_IDL.
- 14.3.1.3.4 Receiver differential input impedance
  - The **differential input impedance** shall be such that any reflection, due to differential signals incident upon the RD circuit from a twisted pair having any impedance within the range specified in 14.4.2.2 shall be at least 15 dB below the incident over the frequency range of 5.0 MHz to 10 MHz. The return loss shall be maintained when the MAU is powered.

- Analysis:
  - Transmit = 3.1V, Receive = 585 mV, ratio = 5.3
  - MDI RL < 15 dB, which is a voltage ration of 5.6
  - The reflection of the transmission is just below the receiver threshold

IEEE 802.3bu-2016

- 96.8.2.1 MDI return loss
  - When a Clause 104 Type A or Type C PI is encompassed within the MDI, the MDI return loss (RL) shall meet or exceed Equation (96–11a) for all frequencies from 1 MHz to 66 MHz (with 100 Ω reference impedance) at all times when the **PHY is transmitting data or control symbols**.

References

- Measurement of MDI return loss during transmission
  - https://www.researchgate.net/publication/268427519_Ethernet_Differential_Return_Loss_Measurement_on_a_Digital_Storage_Oscilloscope
- Independent testing
  - https://www.iol.unh.edu/sites/default/files/testsuites/ethernet/CL96_PMA/Clause96_PMA_Test_Suite_v1.0.pdf
- IEEE 802.3 submissions
  - http://www.ieee802.org/3/bp/public/jan15/pan_3bp_01_0115.pdf
  - http://www.ieee802.org/3/cg/public/July2017/Graber_3cg_11_0717.pdf
  - http://grouper.ieee.org/groups/802/3/bu/public/sep15/gardner_3bu_3_0915.pdf