Noise Environment Characteristics

Contribution to 802.3dm Task Force

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Introduction

- The 802.3dm development should consider the automotive noise environment when evaluating modulation and coding candidates
- The 802.3dm development should consider if there is any difference in the noise environment for balanced pairs and coax cables
- The 802.3dm development should define reference noise environment to use internally when comparing different PHY solutions and line codes
- Specific reference noise models are suggested for 802.3dm line-code evaluation

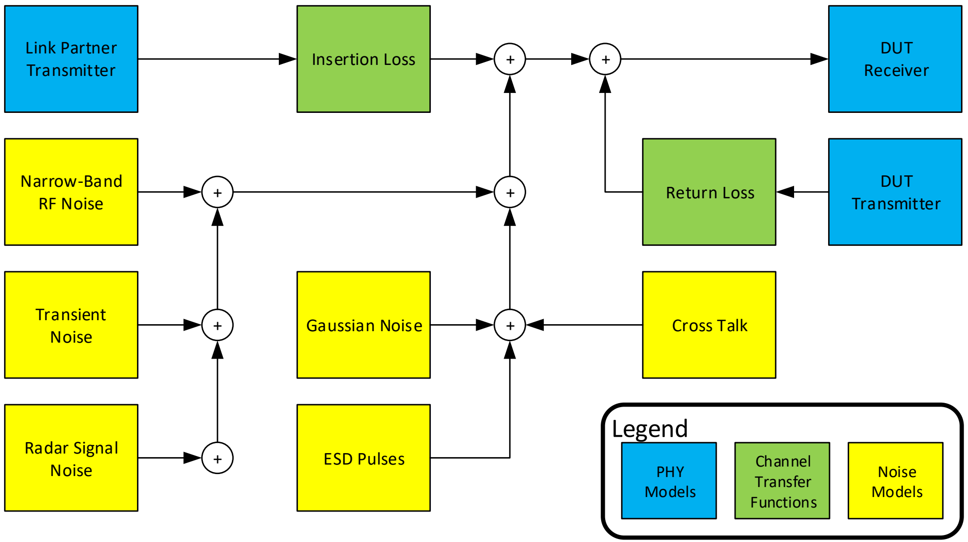
Noise Sources to Consider

The noise sources to consider in the line code evaluation can be roughly divided into two categories:

- Environmental Noise
  - Narrow-band Electromagnetic Interference (EMI)
  - Transient Noise
  - Electrostatic Discharge (ESD) Noise
- Line-Code and Implementation Specific
  - AFE Additive Gaussian Noise (Thermal Noise, etc.)
  - Residual Echo
  - Residual Inter-Symbol Interference
  - Cross-Talk
  - Power Supply Noise

This presentation will primarily focus on the environmental noise

Channel and Noise Model



- There is need for having channel model, when evaluating and comparing line-code candidates
- This presentation focuses on the system noise models (yellow blocks)
- The channel transfer functions (green blocks) can be derived from cable S-parameters
- The PHY models (blue blocks) should include additional noise sources that are internal to the PHYs

This presentation will primarily focus on the environmental noise (yellow blocks)

Some Relevant Requirements and Standards

The following standard were considered when generating this document:

- ISO 11452: Road vehicles - Component test methods for electrical disturbances from narrowband radiated electromagnetic energy
- ISO 10605: Road vehicles – Test methods for electrical disturbance from electrostatic discharge
- IEC 61000-4-3: Electromagnetic compatibility (EMC) Part 4-3:Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test
- IEC CISPR 25: Limits and Methods of Measurement for the Protection of On-Board Receivers (2016)

Modeling Electromagnetic Interference (EMI)

Earlier 802.3 RFI Measurements

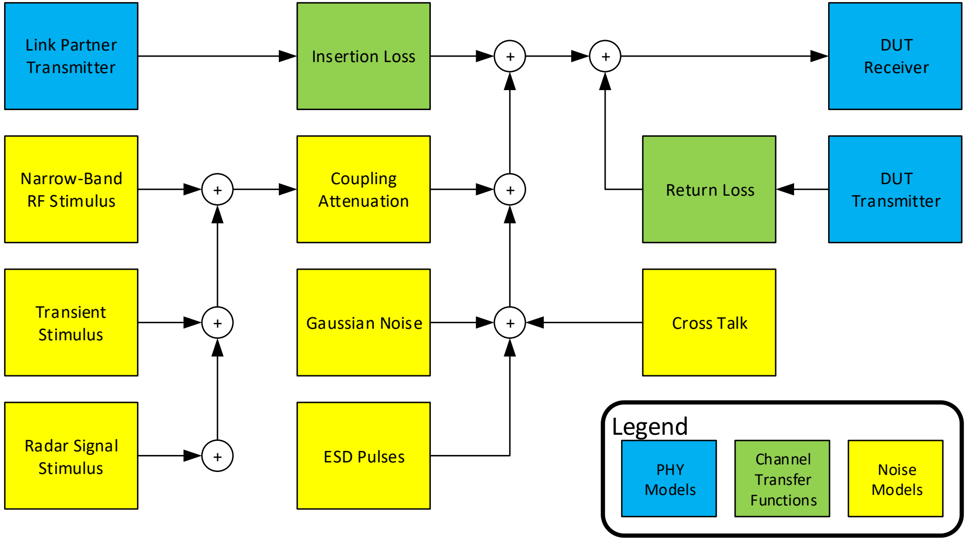
Considerable work has been done on RFI measurements for STP Cables in earlier 802.3 Task Forces. Some examples are:

- https://www.ieee802.org/3/ch/public/nov17/Cohen_Shirani_3ch_01_1108.pdf
- https://www.ieee802.org/3/ch/public/nov17/mueller_3ch_01_1117.pdf
- https://www.ieee802.org/3/ch/public/may18/mueller_3ch_03_0518.pdf
- https://www.ieee802.org/3/ch/public/may18/tu_3ch_01b_0518.pdf
- https://www.ieee802.org/3/ch/public/sep18/farjarad_3ch_01b_0918.pdf
- https://www.ieee802.org/3/cy/public/adhoc/mueller_3cy_01a_11_23_21.pdf

Less information is readily available on Coax Cables

Considerable information available for STP cables, but less information on Coax cables

Channel and Noise Model (Simplified)



- It may be sufficient to simulate the RFI signals using the stimulus signal and a simple model for the Coupling Attenuation

STP Coupling Attenuation (Simplified)

- When evaluating EMI noise, it is important to understand the transfer functions from the EM field into the received signal
- A simple model for this is the Coupling Attenuation Limit specified in Clause 149.7.1.4 of 802.3ch
- The plot on the right shows this Coupling Attenuation transfer function

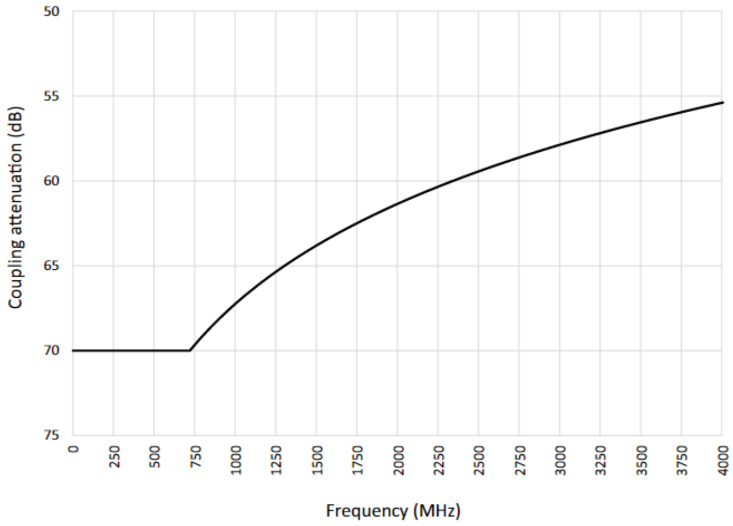


Figure 149–45—Coupling attenuation calculated using Equation (149–24)

Coupling Attenuation Limit can be used as an approximation for coupling transfer function

Environmental Noise Models

Gaussian Noise

- Thermal noise in the integrated circuits of the PHY is the primary source of Gaussian noise in the communication channel
  - Since this noise is somewhat implementation specific and depends on signal bandwidth, this noise is not discussed further in this presentation
- Thermal noise in the coper wires is mostly neglectable (about −174dBm/Hz), compared to other noise sources
- The 1/f noise (pink noise) in coper wires is also mostly neglectable, compared to other noise sources

This presentation will ignore Gaussian noise from the coper wires

Narrow-Band RF Immunity

Standards:

- ISO 11452-4: Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 4: Bulk current injection (BCI).

Test Parameters:

- Frequency: 1 – 400 MHz
- Current Level: up to 106 dBuA
- Dwell Time: minimum 1 seconds
- Modulation:
  - CW (1 – 400 MHz),
  - AM (1 kHz, 80%; 1 – 400 MHz)

Transient Noise

Transient noise sources are often described as fast rising pulses, with slower decay

Such pulses can be modeled with

$$f(t) = K \times (e^{-at} - e^{-bt})$$

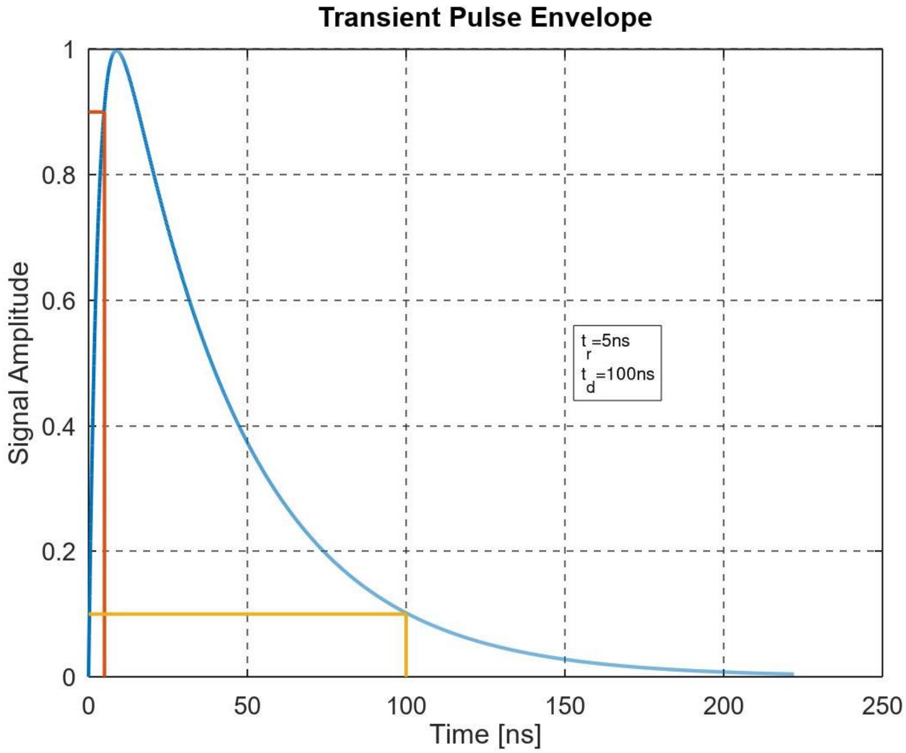
where a and b are chosen based on the rise and decay times and K is chosen to normalize the pulse height

The plot on the right was generated with parameters

a = 26,000,000 [seconds^{-1}]

b = 307,000,000 [seconds^{-1}]

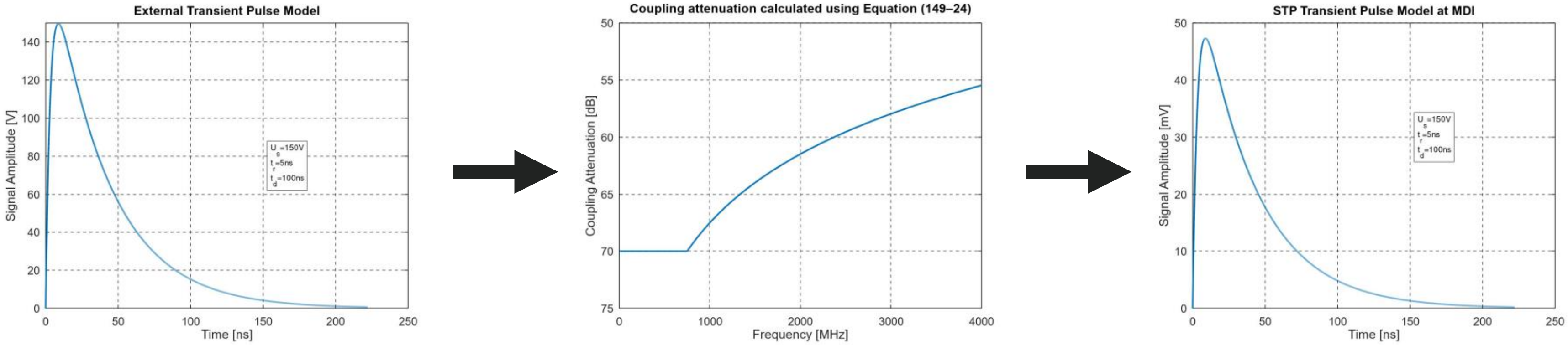
K = 1.3700



Transient Noise Model

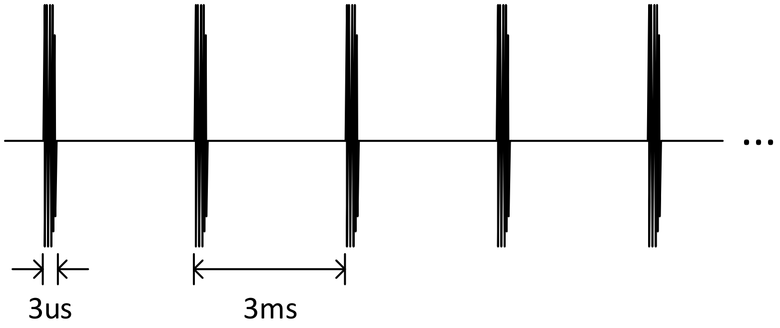
The transient noise can be modeled by adjusting the voltage of the envelope and then pass it through the coupling attenuation to generate the noise at the MDI

Note that this model does not account for any filtering that may take place after the MDI (inside the PHY).



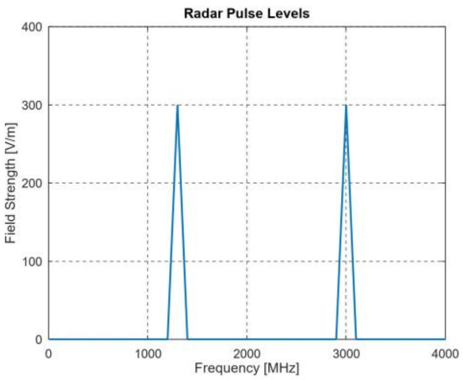
Radar Pulse Immunity

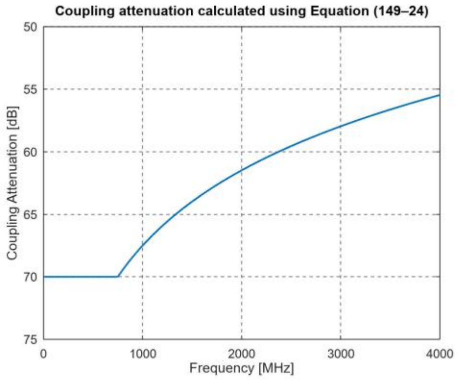
- The radar pulses can be modeled as being in two bands:
  - around1300 MHz
  - around 3000 MHz
- The radar pulses can be in the range from 100V/m to 600V/m
- The radar signal can be modeled as series of pulses where each pulse is 3us with 3ms between pulses

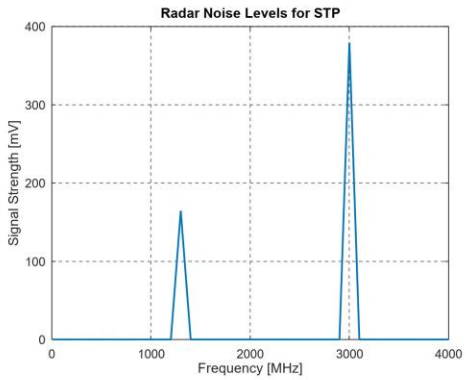


Radar Noise Levels

- The radar pulse will be converted to differential signal at the MDI
- The conversion of the external field strength to signal at the MDI can be approximated by the Coupling Attenuation Limit







Electrostatic Discharge (ESD)

- It is important to account for electrostatic discharge (ESD) in real systems
- ESD testing tends to be focused on the survivability of the PHY and the link, rather than specific performance requirements
- However, ESD pulses have limited impact on line-code evaluation
- Therefore, the modeling of ESD can be skipped in the line-code evaluation

Cross-Talk Noise

- Cross-Talk from adjacent PHYs can be a significant source of interference, and should not be ignored
- The crosstalk coupling functions can be approximated by the PSANEXT and PSAACRF functions from 802.3ch (see plots on the right)
- The nature of the crosstalk will depend heavily on the transmit spectrum and other characteristics of the adjacent PHYs

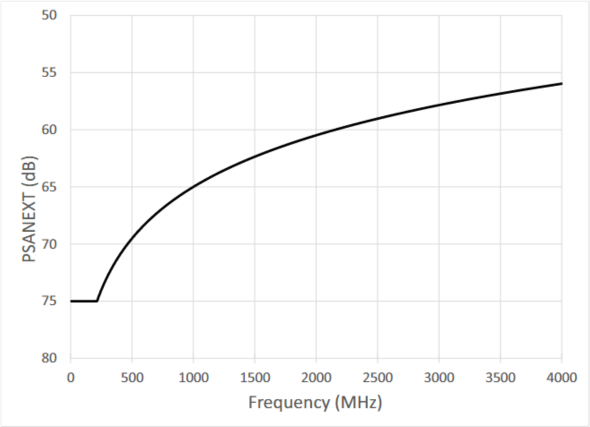


Figure 149–46—PSANEXT calculated using Equation (149–25)

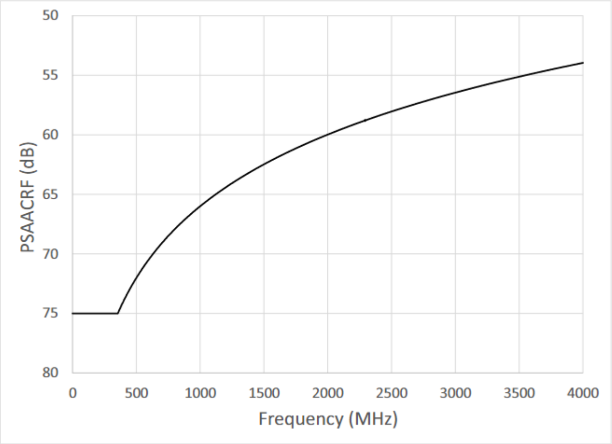
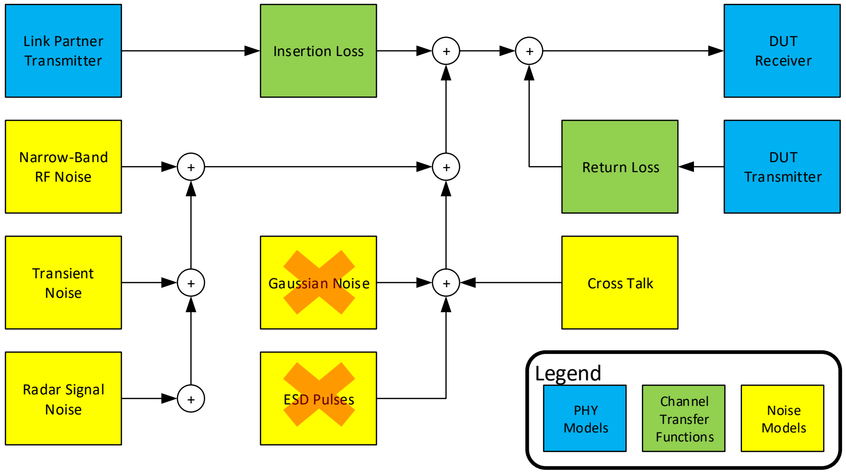


Figure 149–47—PSAACRF calculated using Equation (149–26)

Summary

- This presentation describes model of the environmental noise that may impact 802.3dm line code evaluation
- Specific models have been proposed to describe the environmental noise
- The model is intended to be comprehensive enough to describe the relevant noise sources, without over complicating the model
- Noise modeling may require dedicated ad hoc meeting



All feedback and suggested improvements are greatly appreciated

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