IEEE 802.3dg – Noise Environment Definition

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Overview

- What do we mean by noise environment?
  - Noise has many flavors (depending on the source) and can be modeled in several ways, e.g.
    - White [random, uniform, e.g., Johnson Noise]
    - Gaussian [sum of independent random sources, e.g., Jitter]
    - Impulse [non-stationary, short duration, high peaks, e.g., switching a motor on/off]
    - Tone [stationary CW at specific frequencies, e.g., RF generators]
  - Different applications/environments are typically dominated by different combinations of noise sources
    - The characterization of these sources defines the noise environment
- Why do we care?
  - The kind and amount of noise we have to deal with is critical for the PHY receiver design and may affect the system architecture significantly
  - Noise environments are regulated, and products are tested for conformance
    - E.g., IEC61000-4-4 (EFTs), IEC61000-4-6 (RF immunity)

Applications

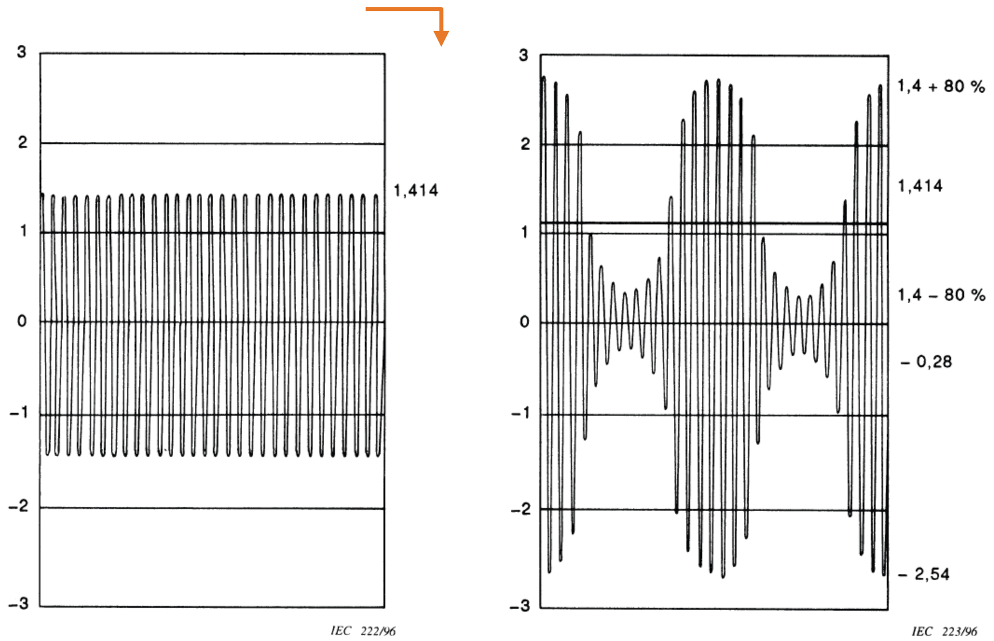
- What application should we consider for 802.3dg?
  - Objective #3: do not preclude meeting FCC and CISPR EMC requirements
- These environments are mainly dominated by impulse and RF noise
- IEC61000-4-4 specifies “Electrical fast transient (EFT) / burst immunity test”
  - That is, immunity to impulse noise
- IEC61000-4-6 specifies “Immunity to conducted disturbances, induced by radio-frequency fields”
  - That is, immunity from RF aggressors

Noise environment definition

Immunity to RF disturbances

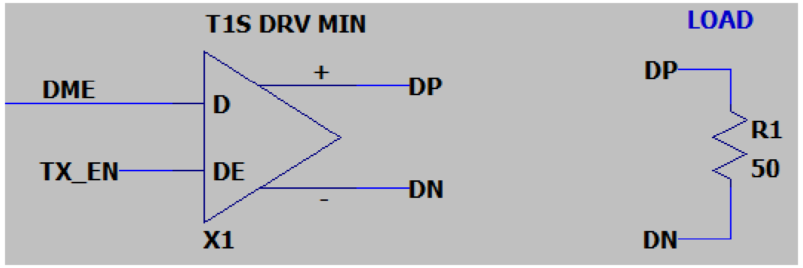
Conducted Immunity (CI)

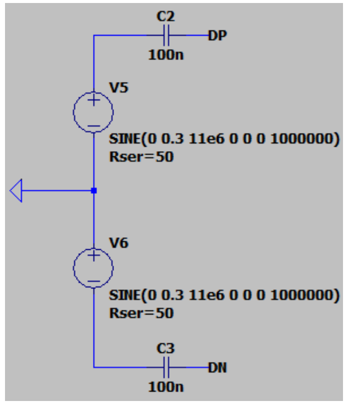
- IEC61000-4-6 models the RF noise in industrial environments as follows
  - Continuous Wave (CW) simulating "intentional" RF transmitters in the frequency range from 150 KHz to 80 MHz.
    - Some OEM requires testing above 80 MHz as well
  - The CW is coupled (CM) to the channel using clamps or CDNs (preferred)
  - The amplitude of the CW is calibrated to be a specific value measured at the MDI
    - during the test, the amplitude is 80% AM modulated by a 1 kHz sine wave
  - The base (unmodulated) amplitude is selected among three classes, according to the application
    - Class 1 → 1 V_{rms} (Low EM radiation environment)
    - Class 2 → 3 V_{rms} (Moderate EM, typical commercial env)
    - Class 3 → 10 V_{rms} (Severe EM, typical **industrial** env)
  - The CW sweeps the frequency range in 1% steps and a minimum of 0.5 s of dwell time (typ. 2 s)

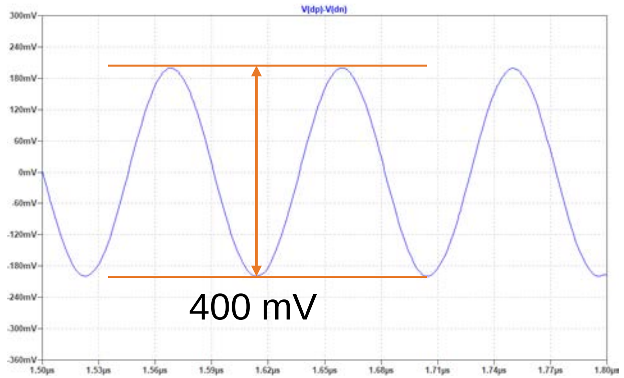


CI effect on a 10BASE-T1S/M link (borrowed example)

- Doing the math:
  - 10 V_{rms} calibrated at the MDI + 80% modulation → 51 $V_{p\text{-}p}$ (max, CM)
  - Considering 43 dB of MC loss (TCTL) → 360 $mV_{p\text{-}p}$ (max, DM)
  - Taking some margin for tolerances/non-idealities → 400 $mV_{p\text{-}p}$ (max, DM)
- Let's have a look at the eye diagrams
  - DISCLAIMER: the presenter is NOT suggesting using eye diagrams as a metric for deriving the receiver performance. But it is a quick & handy way to have a visual feeling.
  - Using the simulations presented already for the TX model https://www.ieee802.org/3/da/public/050422/beruto_3da_20220502_tx_model.pdf
  - Adding a CW of 400 $mV_{p\text{-}p}$ at 11 MHz (in-band)
    - Direct AC coupling







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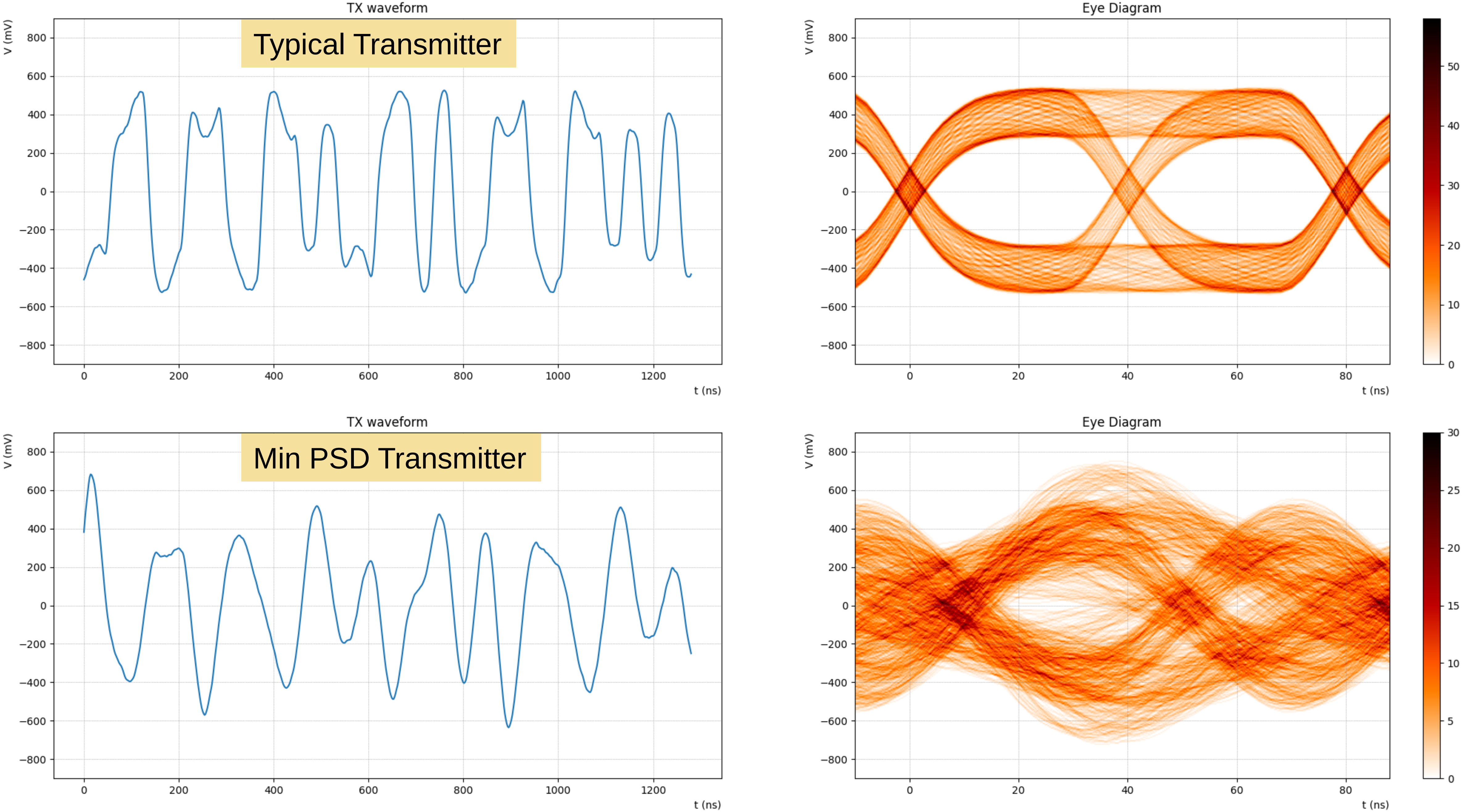


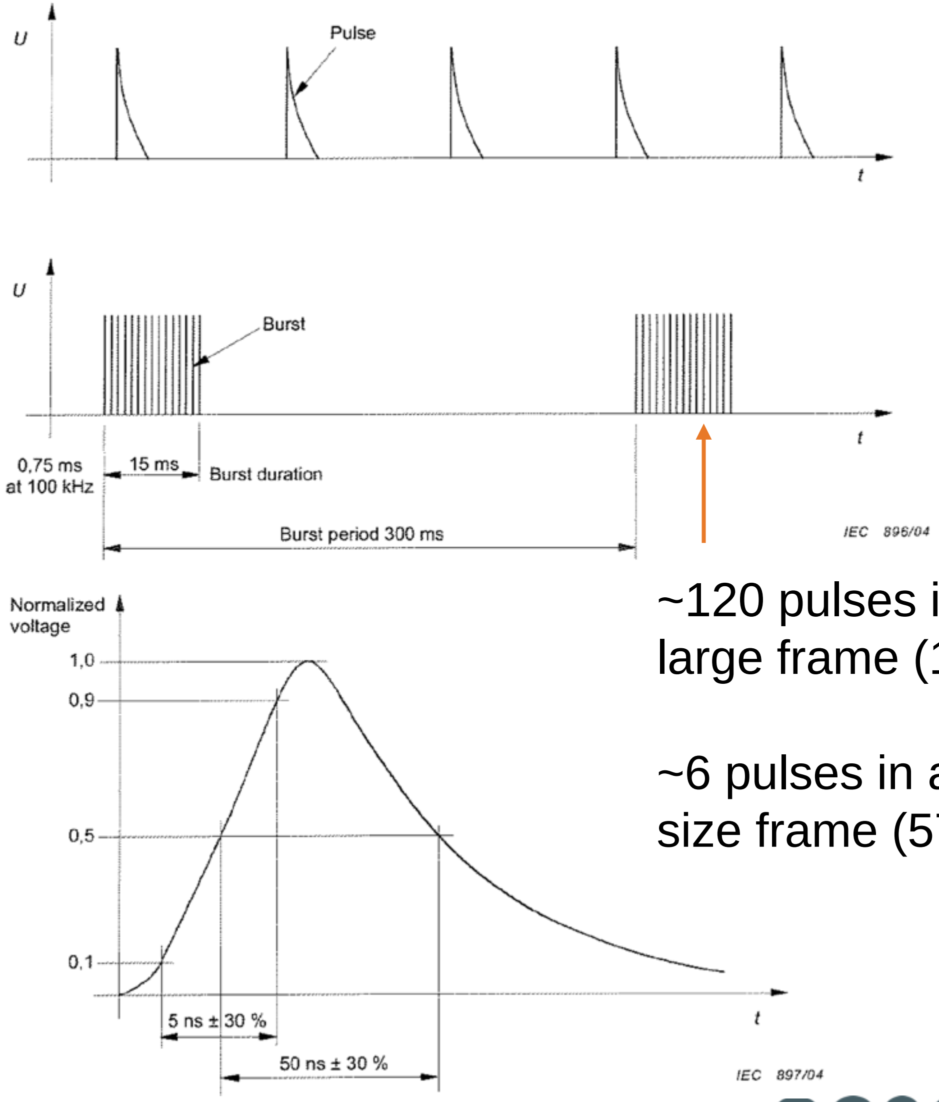
Eye diagrams w/ CW noise

Noise environment definition

Electrical Fast Transients (EFT)

EFT (Electrical Fast Transients)

- IEC61000-4-4 models the impulse noise in industrial environments as follows
  - Calibrated pulses of up to 2kV (CM)
  - Duration: 50 ns (50% to 50%)
  - Rise time: 5 ns
  - Burst rate: 100 kHz (10 µs)
  - Burst duration: 15 ms
  - Burst repetition: 300 ms
- Pulses are calibrated on a 50 Ω load at different peak levels (classes)
  - 250 V (also typical for automotive)
  - 500 V
  - 1 kV
  - 2 kV



~120 pulses in a large frame (1.2 ms)

~6 pulses in a min size frame (57.6 µs)

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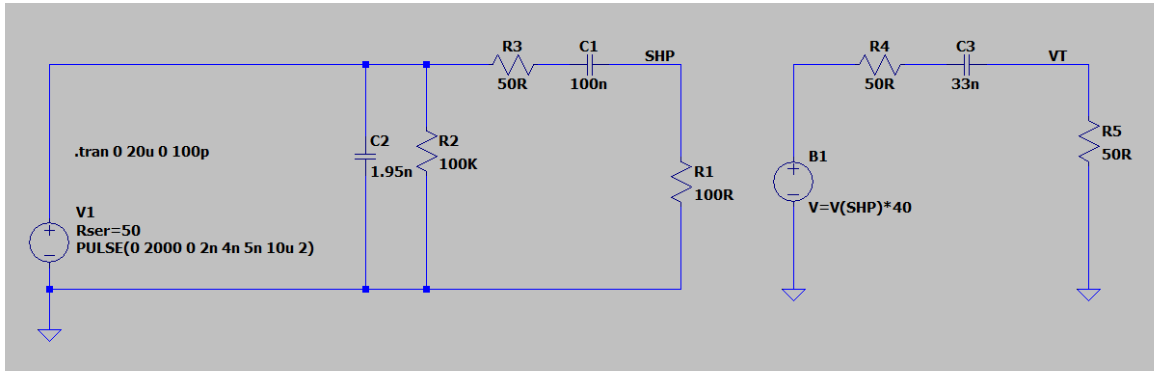
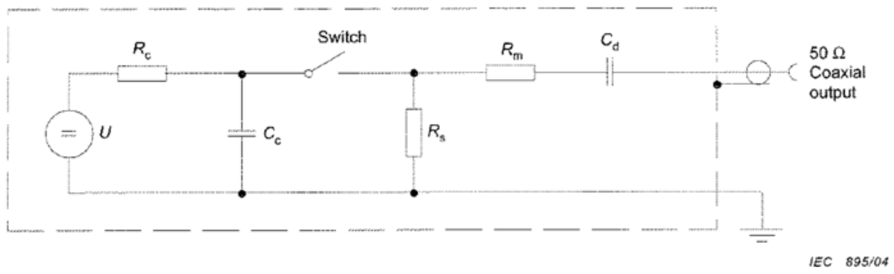
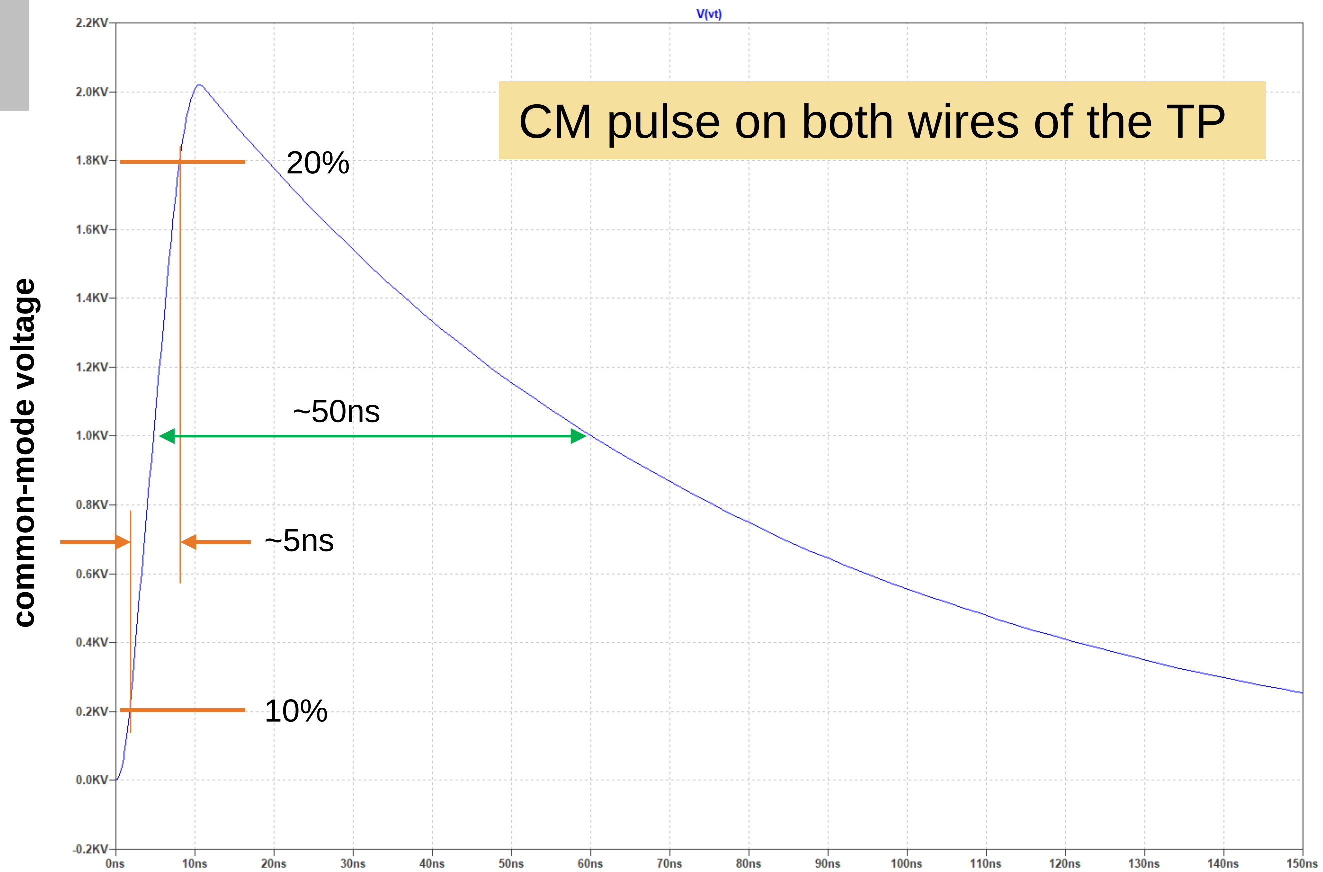
EFT effect on a 50 Ω link (1)





- Model of the impulse noise generator, following IEC61000-4-4 requirements
- Calibrated on a 50 Ω load
- Coupled via a 33 nF capacitor
- 2 kV peak pulse (highest class)



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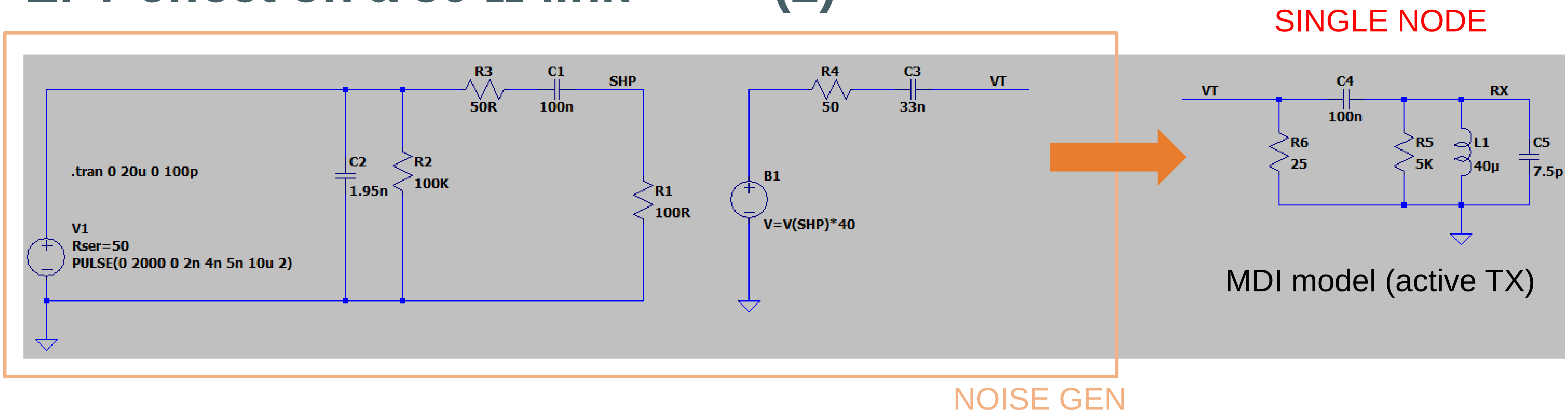
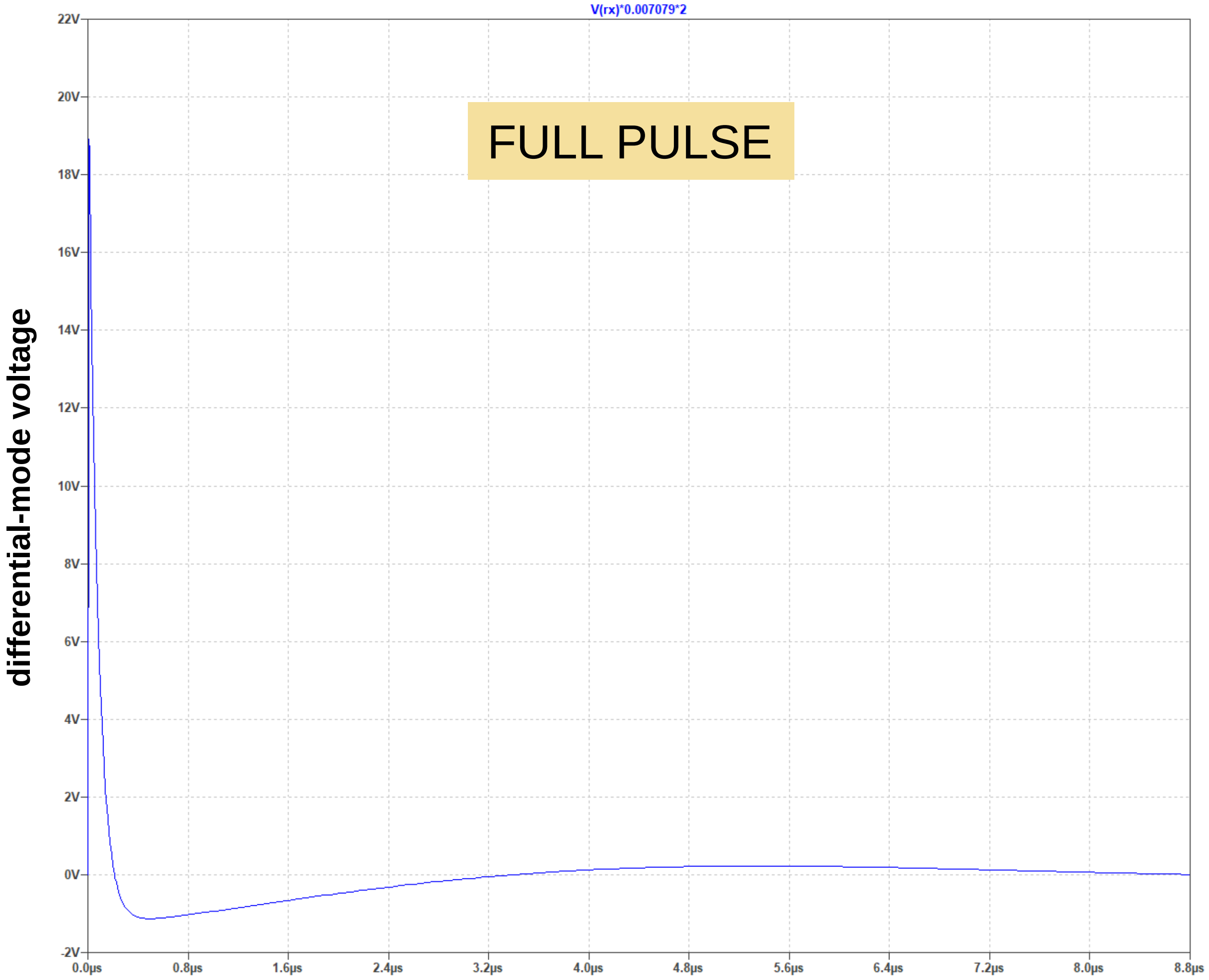
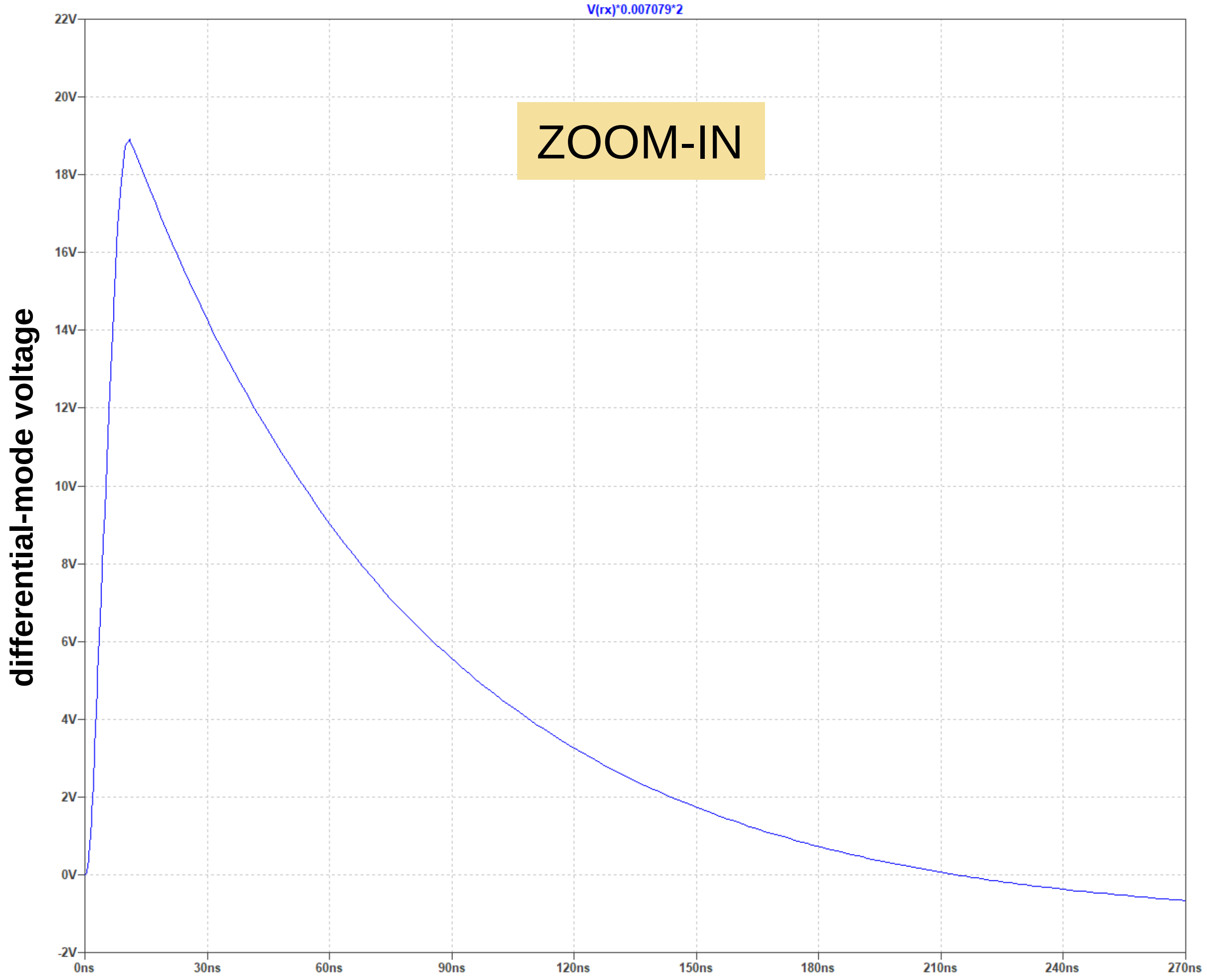
EFT effect on a 50 Ω link (2)



- Considering a mode conversion loss of 43 dB
  - i.e., Transverse Conversion Transfer Loss (TCTL)
    - DM voltage generated by injected CM voltage at the **opposite end** of the segment (or vice-versa)
    - Not to be confused with TCL which is the CM voltage reflected back at the injection point
  - For simplicity, flat on all frequencies → DM pulse is the CM pulse lowered by 43 dB
    - In reality, MC degrades at higher frequencies, but we assume an LPF in the receiver to compensate
    - This is just an estimation!

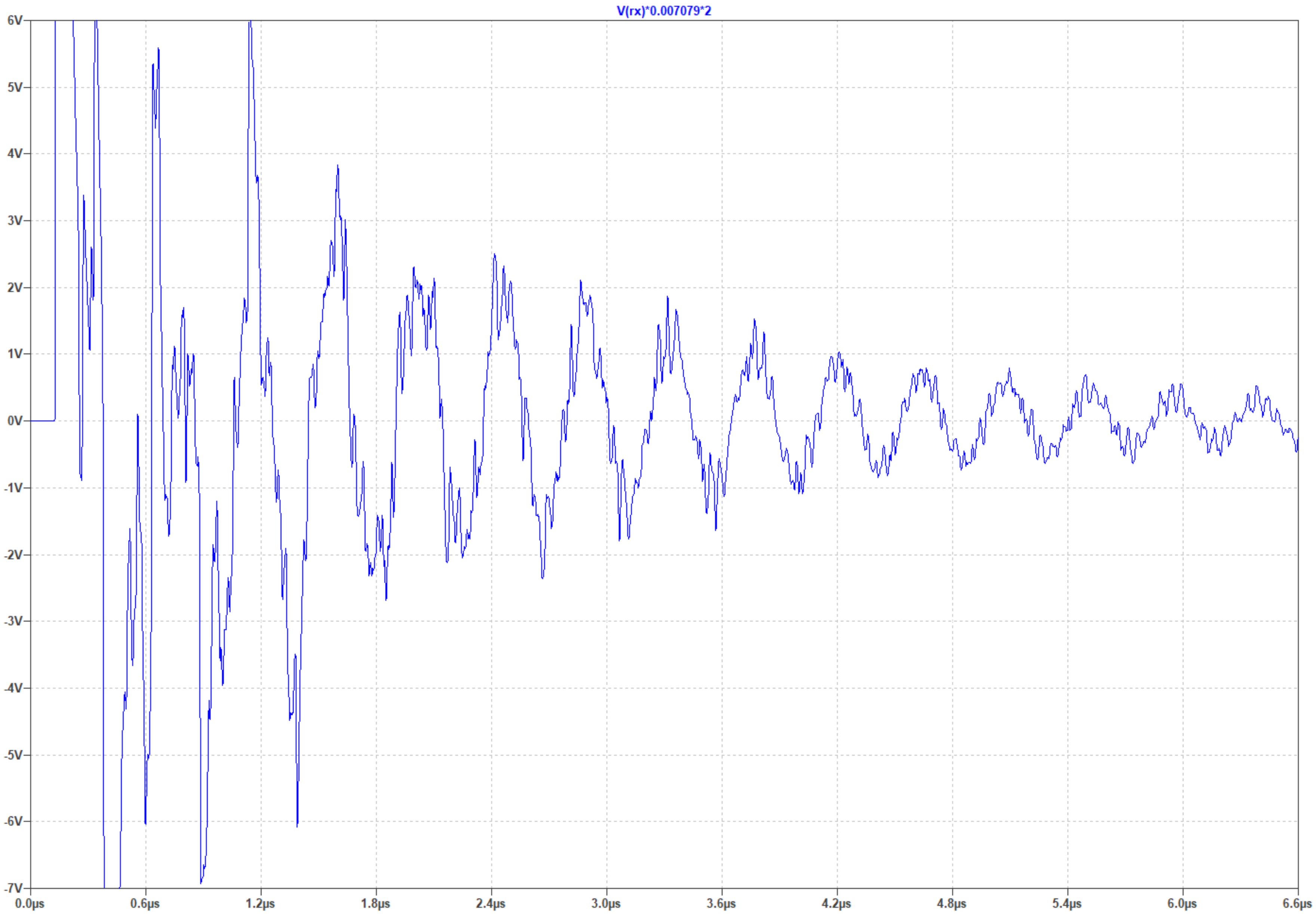
EFT effect on a 50 Ω link (3)





- Differential mode noise is way higher than the nominal TX amplitude (1 $V_{p\text{-}p}$)

EFT effect on a 50 Ω link (4)



- In real-life, EFT pulses are unlikely that smooth!
- This is an example of what you could see on a non-ideal system.
- See also https://www.ieee802.org/3/cg/public/Mar2017/Graber_3cg_01a_0317.pdf
- https://www.ieee802.org/3/NGEBASET/public/entnoise/Shirani_NGEABT_03_0315.pdf

How to deal with EFT then?

- Work is needed to explore what the architecture can and cannot compensate for
- The EFT test is a system-level test, including the higher layer protocols
  - It is allowed, for example, to have re-transmissions to meet the BER requirements
    - The bursts are limited in time (15 ms) and repeat infrequently (300 ms)
    - Most applications can tolerate this

Conclusions

Conclusions

- According to 802.3dg objectives, we shall not preclude meeting FCC and CISPR EMC requirements
  - Propose to follow IEC61000-4-4 and IEC61000-4-6 to define the noise environment for 10BASE-T1M
    - Propose to define multiple receiver performance classes (as in IEC61000-4-6)
    - Work is required to deal with EFT, or solve the problem in the higher layers (re-transmissions)
- The challenges for meeting the receiver's performance have been presented
  - Propose to define a minimum receiver model to compare with
  - Propose to define a receiver performance metric

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