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Noise considerations for RTPGE objectives

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Preface

- Close to moving out of study group phase
- Presentations have been made on automotive requirements for EMC, power, lifetime, link specification etc.
- Some capacity analysis
  - http://grouper.ieee.org/groups/802/3/RTPGE/public/july12/huang_01_0712.pdf
  - http://grouper.ieee.org/groups/802/3/RTPGE/public/july12/mei_01_0712.pdf
  - But analysis presented so far excludes some important items that will influence choice of modulation scheme, cable type, signaling rate, latency, FEC, training etc.

Recap – Shannon capacity / Salz SNR

- Shannon capacity of a narrow frequency band of width B in AWGN is W*log2(1+S/N) in bits per second
- Integrate over entire frequency range to calculate capacity of the channel
  - Shannon does not specify a method to achieve capacity

- Salz bounds the SNR achievable with a Decision Feedback Equalizer
  - Simple receiver
  - Assumes infinite length filtering
  - Assumes perfect decisions
- Both approaches depend on estimates of the noise power across frequencies

What is noise?

- Noise = self noise + alien noise
- Self noise is residual interference caused by our own signal that is uncancelled
  - Residual ISI, Residual NEXT, Residual FEXT
- Alien noise is energy that is not due to the signal of interest
  - Energy on the wire when the transmitter we care about is not active
- High data rates for RTPGE require higher signal bandwidths/higher order modulations, increasing the receiver exposure to noise sources
- Automobile dynamics mean noise may be hard to predict and control

Capacity/SNR analysis

- Included so far…
  - Residual near end, far end, alien crosstalk and (for Salz) inter-symbol interference
- Baseline capacity and SNR numbers for some existing cable types have been presented
  - MMSE analysis for ISI
    - Salz analysis assumes infinite length FFE/DFE
- Some results included the use of flat -140dBm/Hz background noise
  - as in 802.3an (10GBASE-T) specification
- Residual echo not included in numbers shown in huang_02_0712.pdf

Additional background noise

- Measurements in data-centers were taken for 10GBASE-T project to validate noise level assumptions
- Entirety of background noise may not be modeled in previous analysis
  - Power train noise (petrol/diesel/hybrid vehicle differences?)
  - Digital electronics emissions (ECMs)
  - Motors / air conditioning etc.
  - See http://www.ofcom.org.uk/static/archive/ra/topics/research/topics/emc/powertrain-emissions.pdf
    - What is the mean noise level?
    - Is it shaped?
    - Are narrowband interferers present?
    - Is it well modeled by AWGN?
  - We should measure this noise to determine whether it affects channel capacity

Noise from narrowband interferers - EMI

- **Narrowband interferers do not significantly affect Shannon capacity**
  - Narrow frequency range of signal is affected
    - Dependent upon interferer bandwidth (1kHz for CISPR)
  - Shannon capacity in a narrow frequency range can approach zero without overall link channel capacity changing significantly
- Out-of-band interferers can be filtered in the analog front end before the ADC
- **But**.. in-band interferers are more difficult to separate from the desired signal and are typically cancelled after the A/D -> should be included in loading analysis?
  - Front end requirements tend to dominate long-term achievable power/cost
  - Some common approaches for robust performance in the presence of NBI reduce systems performance (SNR), can limit link capability and/or add complexity
- Good design (balance etc.) can limit coupling of external sources but it may be hard to eliminate the effect of NBI completely

Noise from narrowband interferers - EMI

- **The environment for RTPGE is significantly different from a data-center**
- A automobile in motion may interact with multiple dynamic external interferers **at the same time**
  - TV and radio transmissions (continuous), walkie-talkies, MPT1237, wireless microphones, TETRA, keyless entry, wireless tire pressure monitoring etc.
- Cabling harness is close to other sources of interference with near field characteristics
  - Near glove compartment and car occupants – cellphone, pagers, walkie-talkies, ham radio?
- When these interferers appear or disappear the link should maintain desired link quality
- **EMI requirements should be included in system analysis to avoid under/over designing system**

Narrowband interferers - tests

- Narrowband EMI is included in automotive testing requirements
- Automotive EMI interferer tests use high field strengths
  - e.g. some manufacturers have requirements for 100V/m+ field strengths compared to typical 3-10V/m for Ethernet (typically in industrial environ.)
  - stress front-end headroom and linearity
- Typical EMI testing appears to cover one narrowband disturbance at a time
  - There are many manufacturer tests with different signal levels, modulation, frequency ranges etc.
- Are these worst case conditions for RTPGE?
  - Need to understand manufacturer testing goals and how the tests compare to the real environment

Impulse noise

- Effect of impulsive, wideband noise should be analyzed
  - Do we need to consider other EM transients?
    - engine ignition [self or adjacent] and turn off
    - static discharge
    - lightning?
  - Impulse noise can be tolerated with error correction coding / interleaver / impulse noise detection
    - Adds latency / cost (memory)
  - Not generally specified for 802.3 PHYs but used in other standards e.g. DOCSIS, DVB
- Should we develop an impulse noise model?

What to do?

- We could define worst case differential mode / common mode noise tolerated by PHY
  - How to specify this? How to measure?
- We could use a specific environmental EMI / alien noise model to evaluate PHY proposals
  - How do we design this model?
    - Based on existing automotive EMI test scenarios
    - Take measurements to correlate with real environment
- Other options?

- Define reliability requirements
  - E.g. robustness of media system transport vs powertrain

Conclusions

Conclusions

- Form a noise modeling ad hoc and invite presentations
  - Can automotive vendors provide initial background noise measurements from the cable harness?
  - Consult with vendors re: existing EMI test requirements
    - Develop test levels, models etc.
  - Determine need for impulse noise model and develop if necessary
- Enable PHY vendors to
  - Perform initial front-end/loading analysis
  - Develop simulations to model receiver capability / capacity impact / reaction time for typical receiver architectures, and investigate training algorithms and robustness
  - Compare PHY options

Potential objectives

1. Define the worst-case noise conditions for RTPGE applications including background noise, impulse noise and EMI environment
2. Determine reliability requirements for RTPGE applications
3. Define a PHY to meet the reliability requirements in the defined worst-case noise environment

Thank you

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