Bit error rates and correlation results for Common-Mode aided communications

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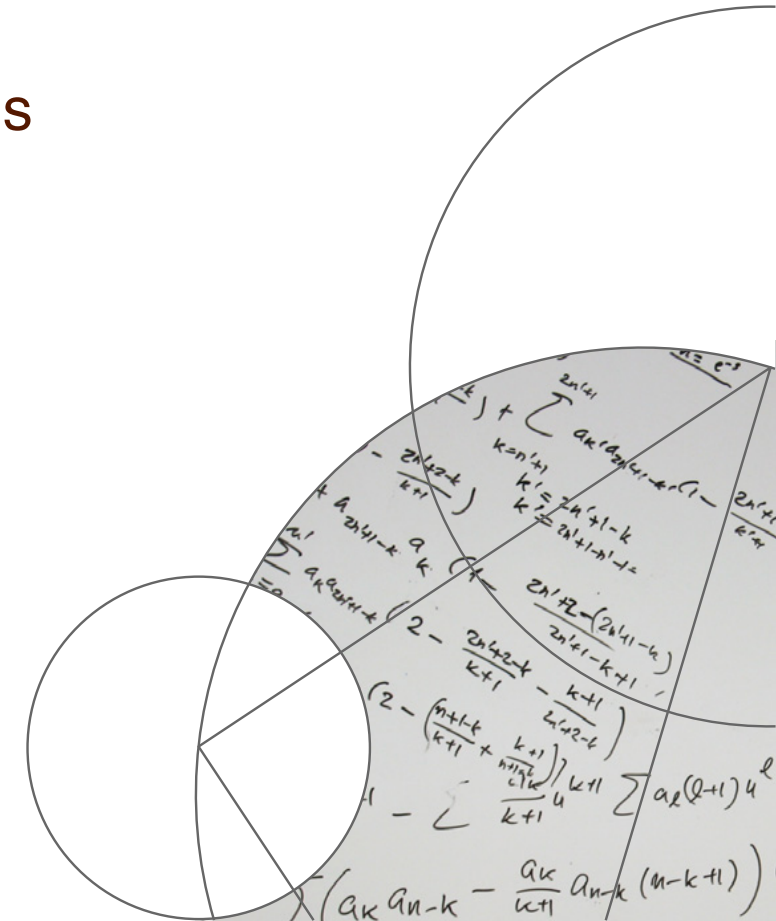
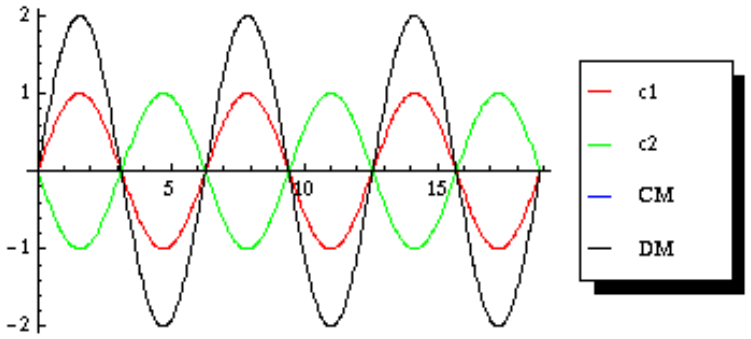
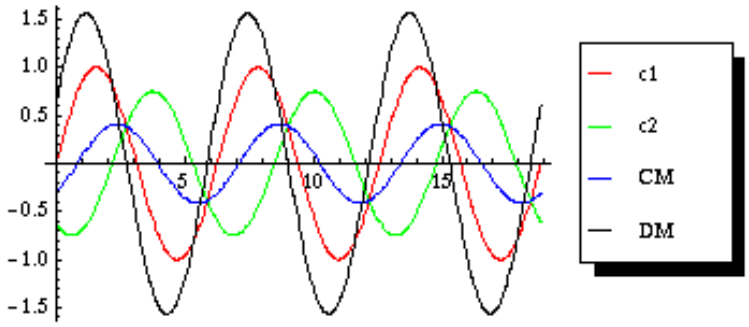


Overview

- DM and CM signals
- DM and CM correlation
- Canceller Structure
- Channel Model
  - Transfer Functions
  - Coupling Functions
- Cancellation
- Results

Differential- and Common-mode signals





DM signals

- sent on 2 wires, opposite polarity with respect to GND.
- RX measures signal difference between wires
- higher immunity to interference, improved SNR

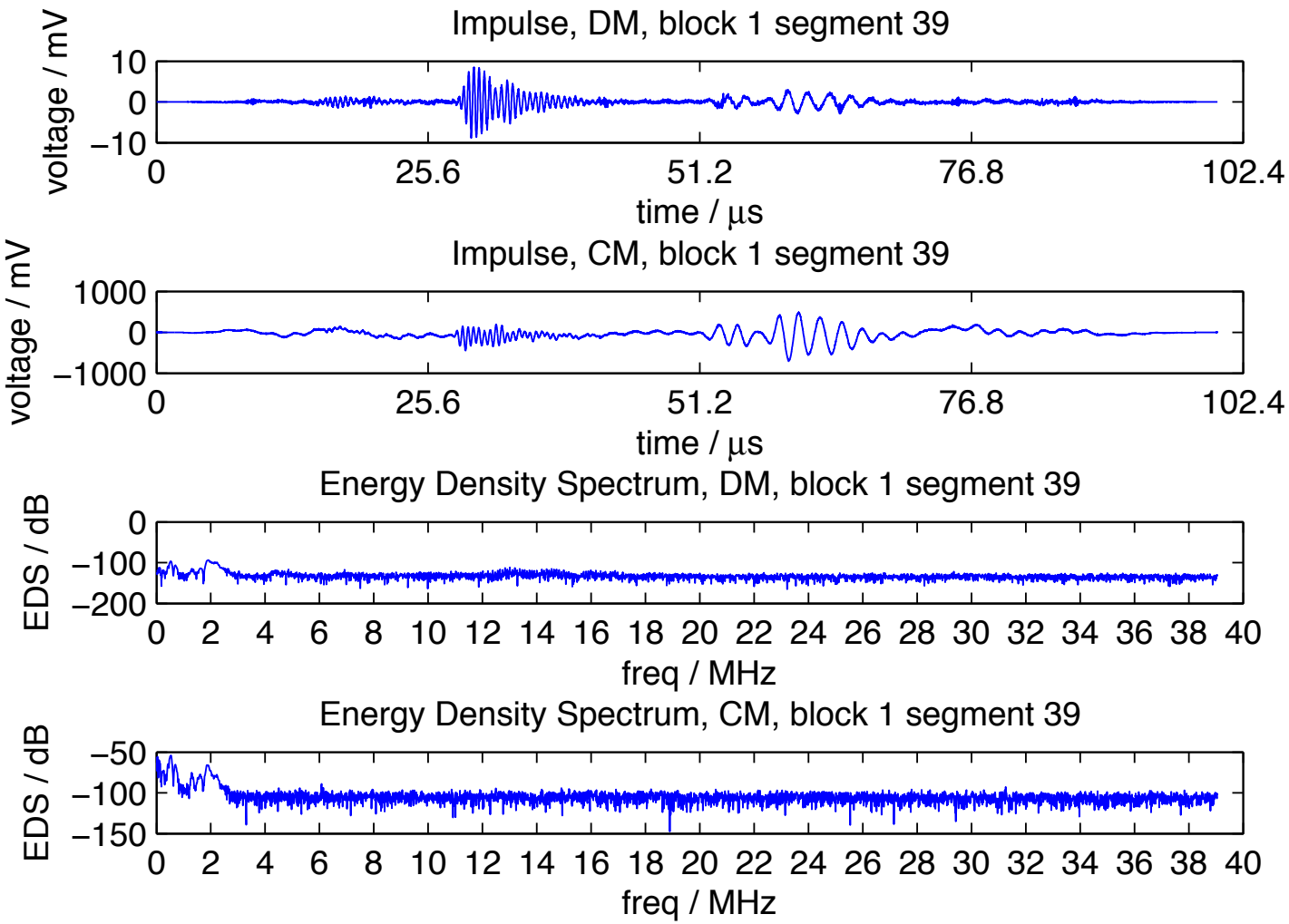
$$x_{DM}(t) = x_1(t) - x_2(t) \quad (1)$$

CM signals

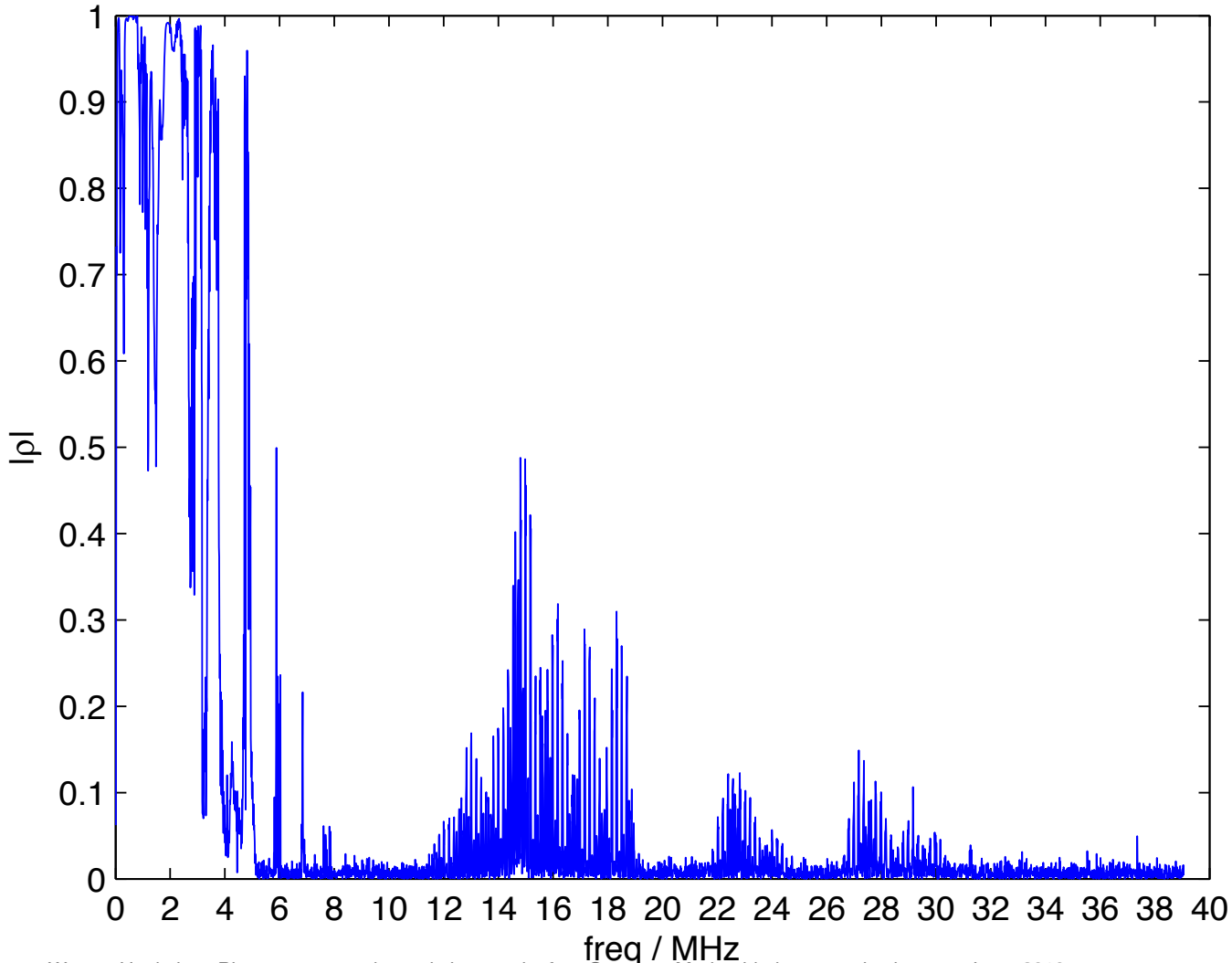
- appear on both lines on a 2-wire cable
- measured at center tap of transformer
- noise couples higher

$$x_{CM}(t) = \frac{x_1(t) + x_2(t)}{2} \quad (2)$$

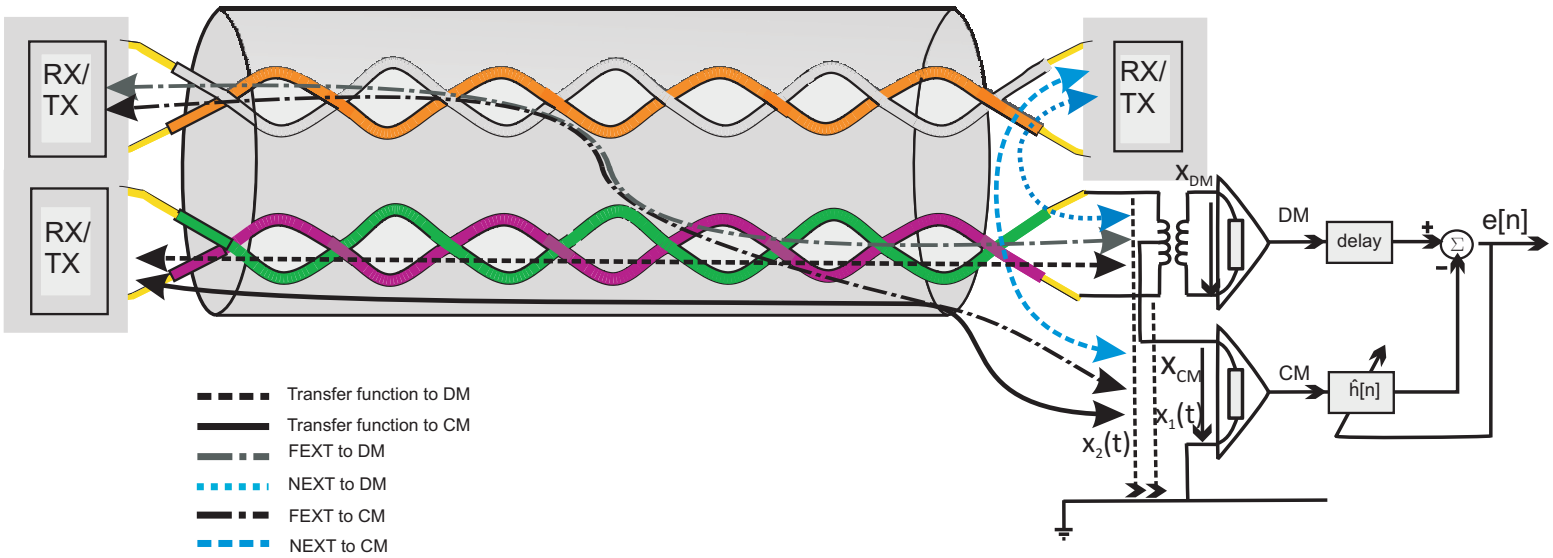
Impulse noise, DM and CM



DM and CM correlation



CM canceller structure



- detect impulse noise in CM - threshold
- NLMS filter
- simulations based on measurements

Channel model

$$\mathbf{y}_j^{DM} = \mathbf{H}_{j,j}^{DM} \cdot \mathbf{s}_j + \mathbf{H}_{FEXT}^{DM} \cdot \begin{bmatrix} \mathbf{s}_1 \\ \vdots \\ \mathbf{s}_{j-1} \\ \mathbf{s}_{j+1} \\ \vdots \\ \mathbf{s}_{L+1} \end{bmatrix} + \mathbf{H}_{NEXT}^{DM} \cdot \begin{bmatrix} \mathbf{v}_1 \\ \vdots \\ \mathbf{v}_K \end{bmatrix} + \mathbf{w}^{DM} + \mathbf{i}^{DM} \tag{3}$$

$$\mathbf{y}_j^{CM} = \underbrace{\mathbf{H}_{j,j}^{CM} \cdot \mathbf{s}_j}_{\textit{negligible}} + \mathbf{H}_{FEXT}^{CM} \cdot \begin{bmatrix} \mathbf{s}_1 \\ \vdots \\ \mathbf{s}_{j-1} \\ \mathbf{s}_{j+1} \\ \vdots \\ \mathbf{s}_{L+1} \end{bmatrix} + \mathbf{H}_{NEXT}^{CM} \cdot \begin{bmatrix} \mathbf{v}_1 \\ \vdots \\ \mathbf{v}_K \end{bmatrix} + \mathbf{w}^{CM} + \underbrace{\mathbf{i}^{CM}}_{\textit{dominant}} \tag{4}$$

$$\mathbf{H}_{FEXT}^{DM} = \left[\mathbf{H}_{j,1}^{DM} \cdots \mathbf{H}_{j,j-1}^{DM} \mathbf{H}_{j,j+1}^{DM} \cdots \mathbf{H}_{j,L+1}^{DM} \right]_{(N_X[N_X L])} \tag{5}$$

$$\mathbf{H}_{NEXT}^{DM} = \left[\mathbf{H}_{j,L+1}^{DM} \cdots \mathbf{H}_{j,L+K}^{DM} \right]_{(N_X[N_X K])} \tag{6}$$

$\mathbf{w}^{DM}$ = AWGN coupled into DM; $\mathbf{i}^{DM}$ = DM coupled impulse noise; $\mathbf{s}_j$ = transmitted signal of size *Nx1* on pair *j* $\mathbf{H}_{j,j}^{DM}$ is the *NxN* convolution matrix describing the DM to DM path on *j*th pair;

DM and CM Transfer Functions

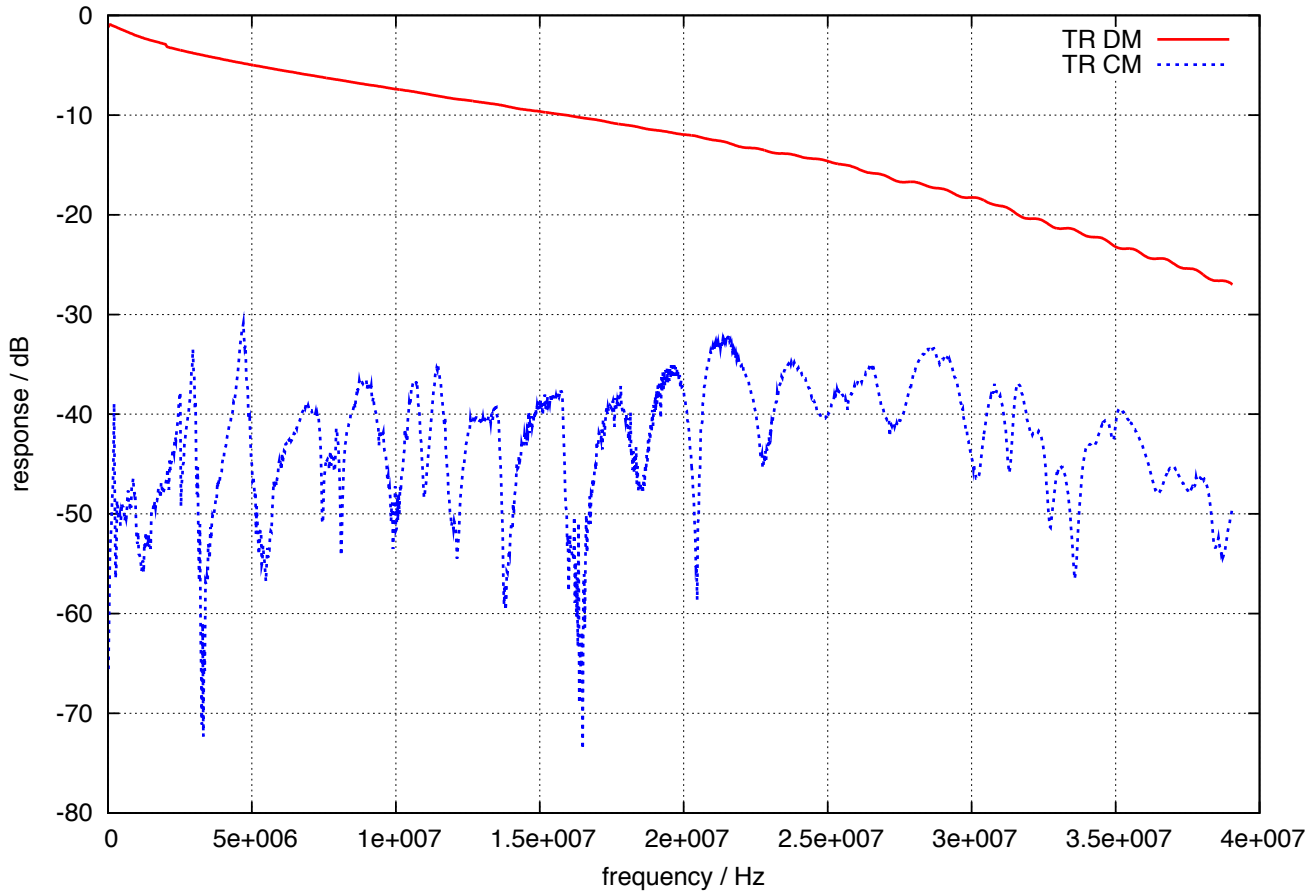
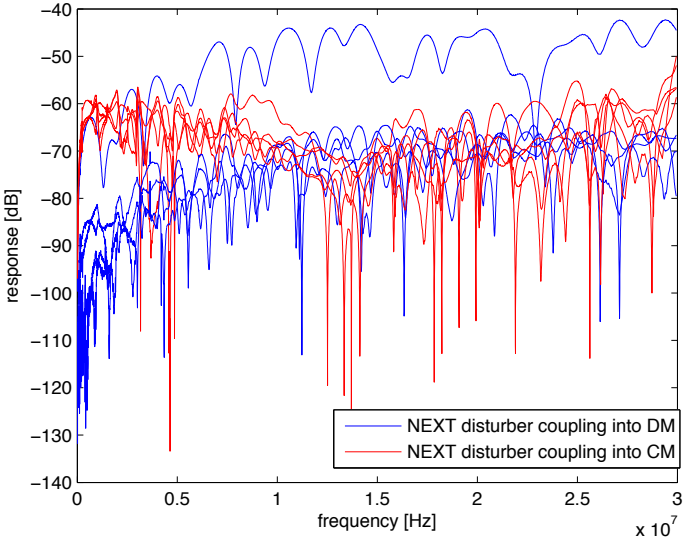
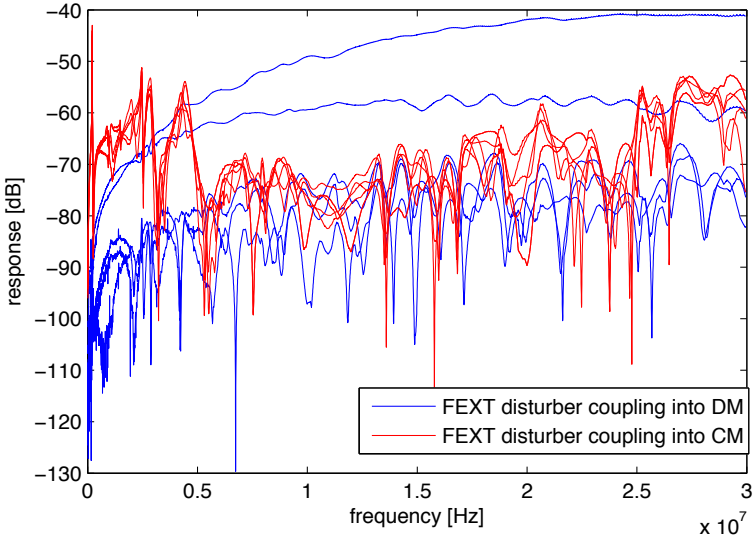


Figure: Measured DM and CM transfer functions

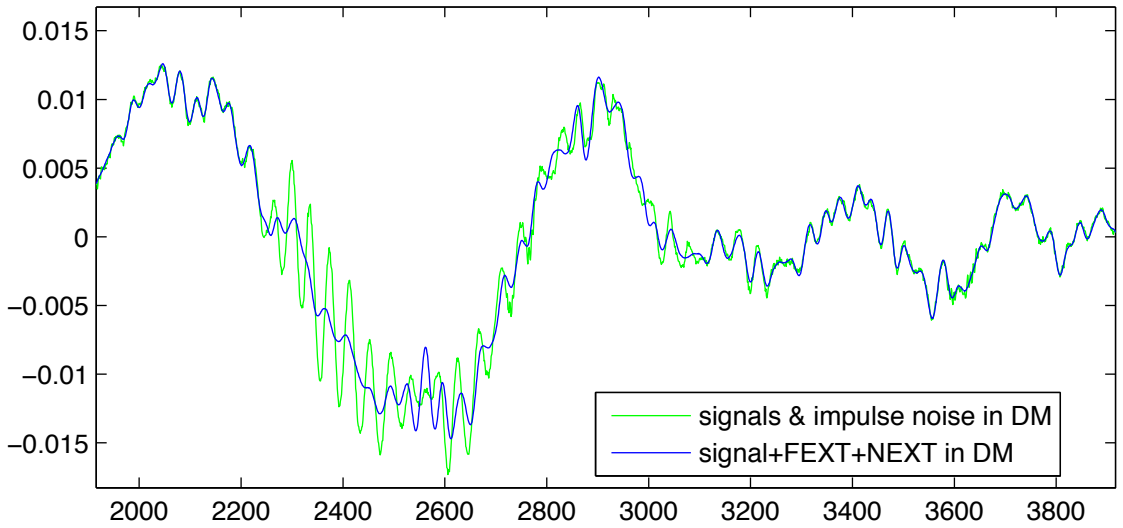
NEXT and FEXT coupling functions



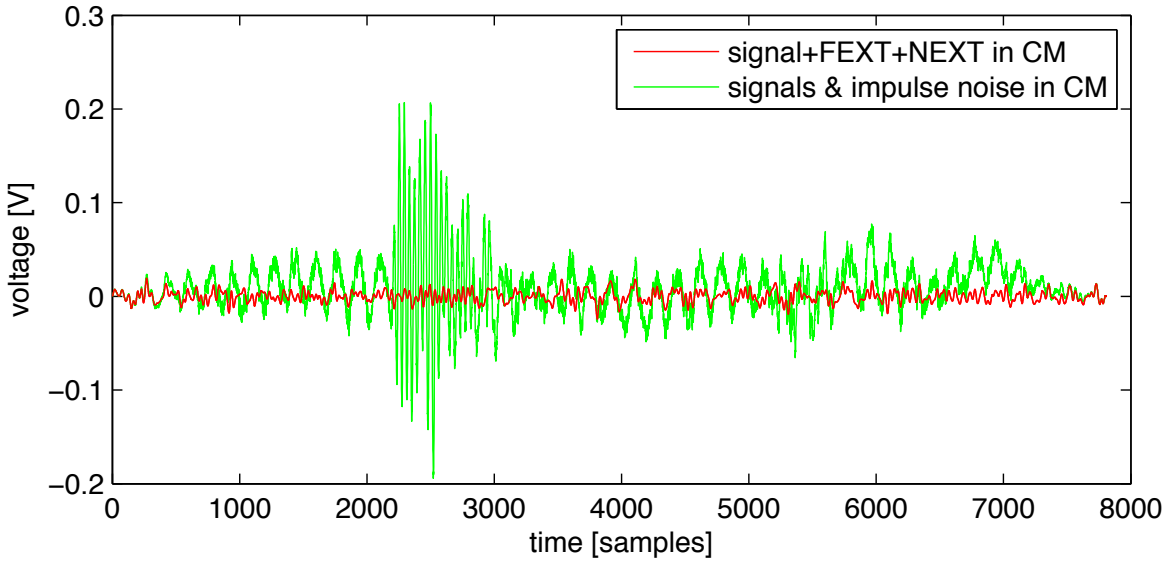


- measured coupling functions into DM and CM for different adjacent pairs
- applied NEXT and FEXT spectral masks
- generated NEXT and FEXT disturbers with correponding spectra

Received signals

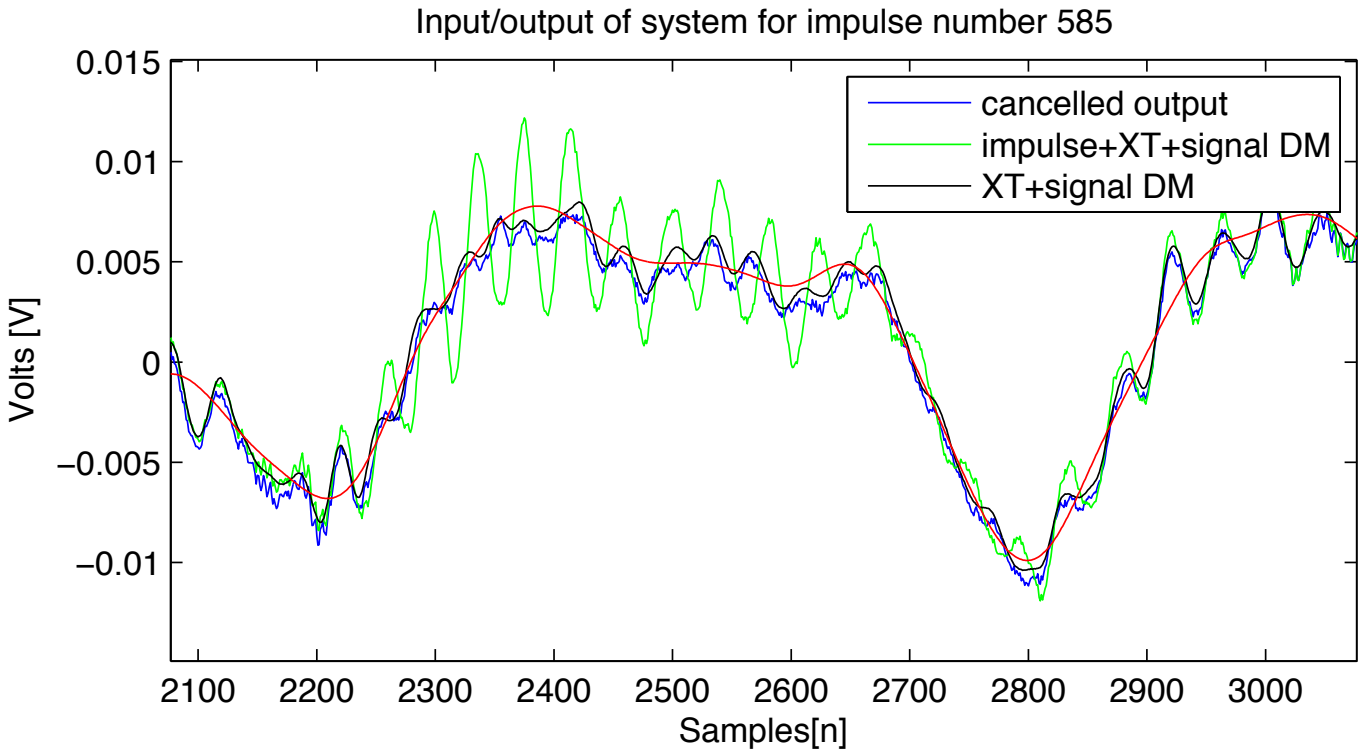


DM

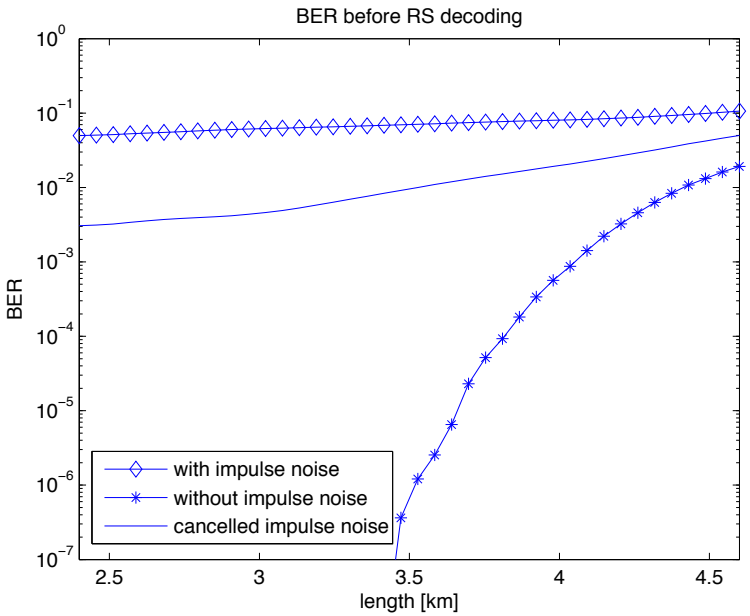


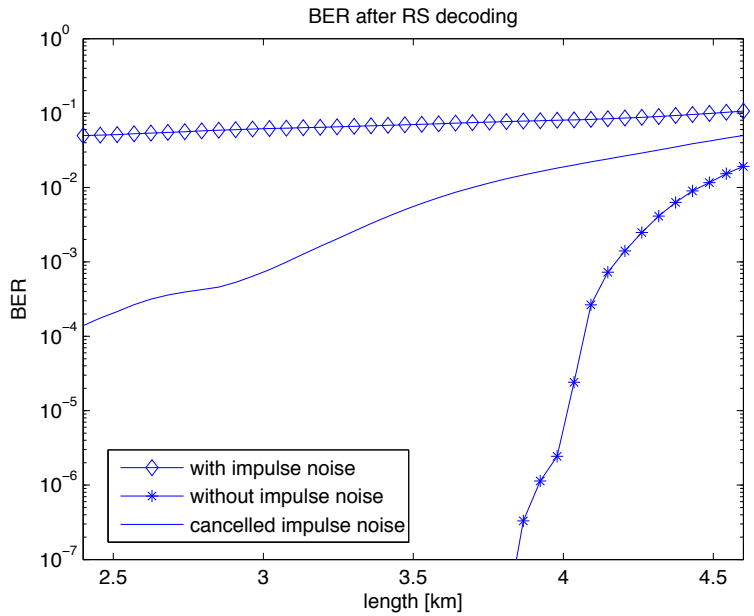
CM

Results for NLMS



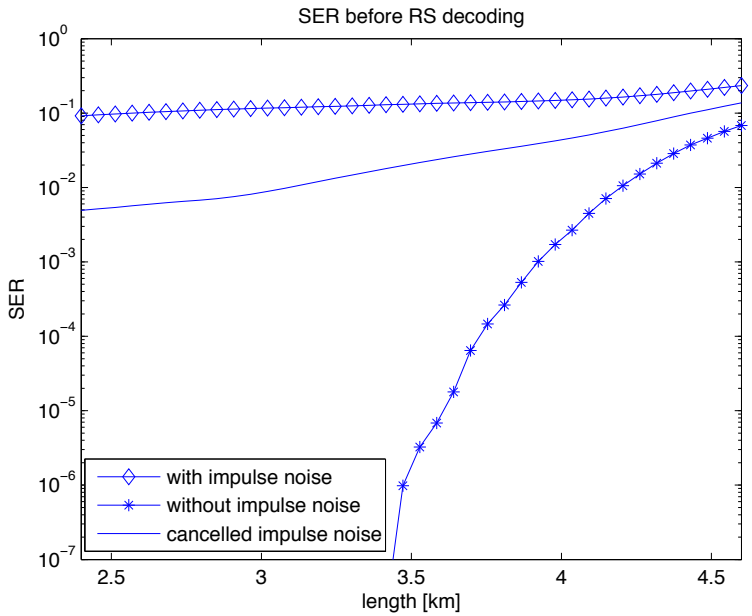
Bit-error Ratio

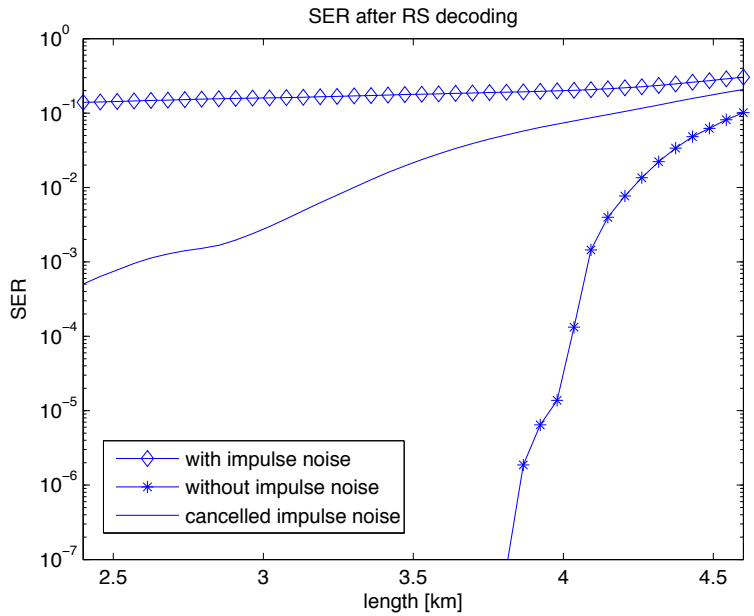




- background noise level −120 dBm/Hz
- 5 NEXT disturbers
- DM impulse amplitude 1 V
- constant interarrival time

Symbol-error Ratio





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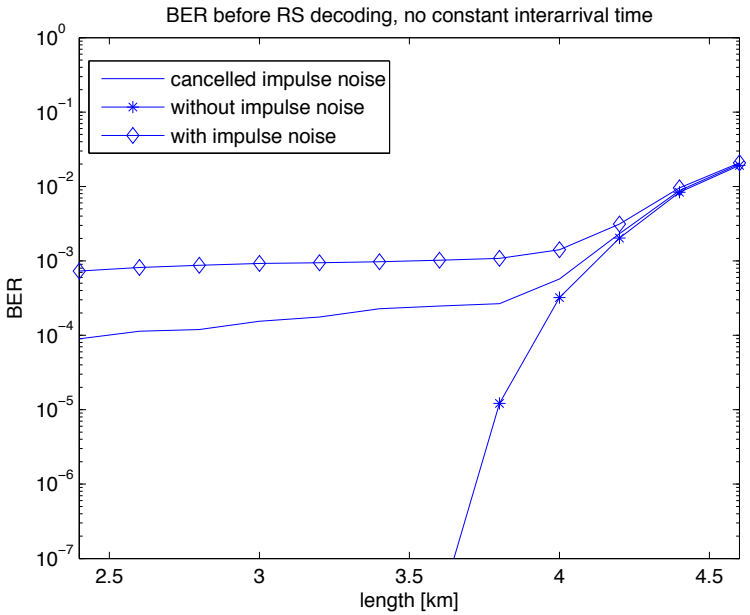

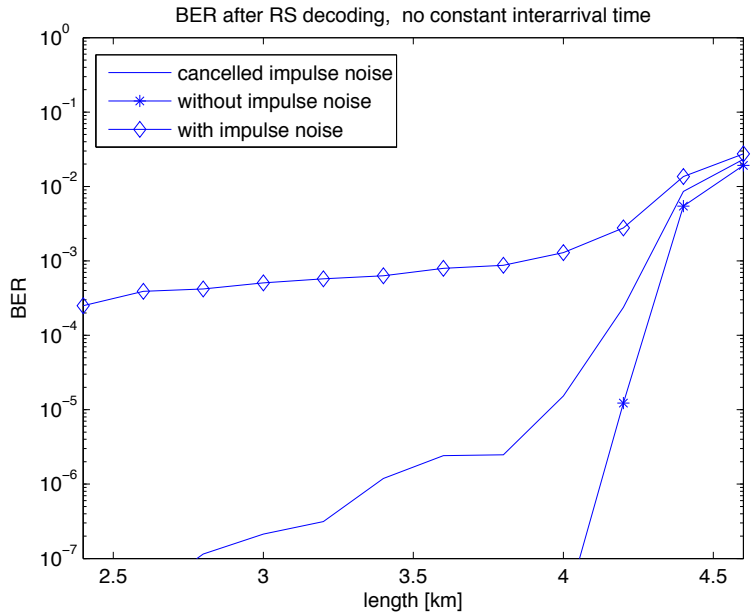

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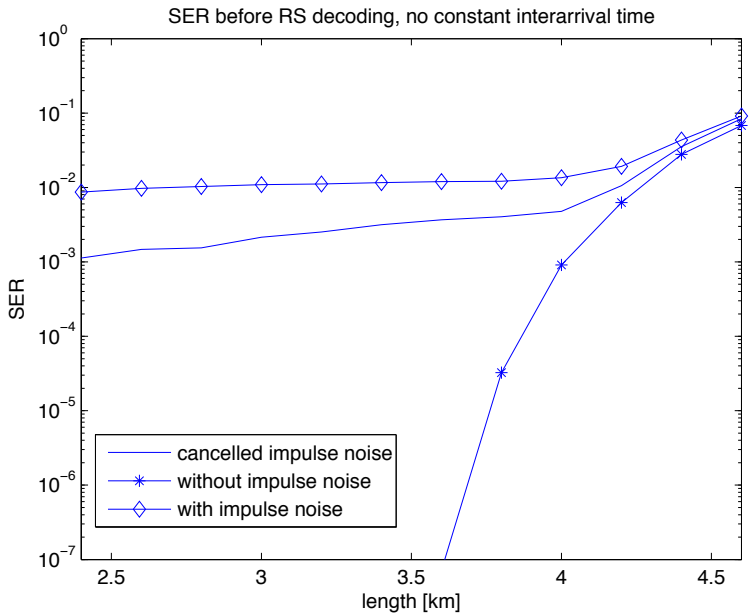
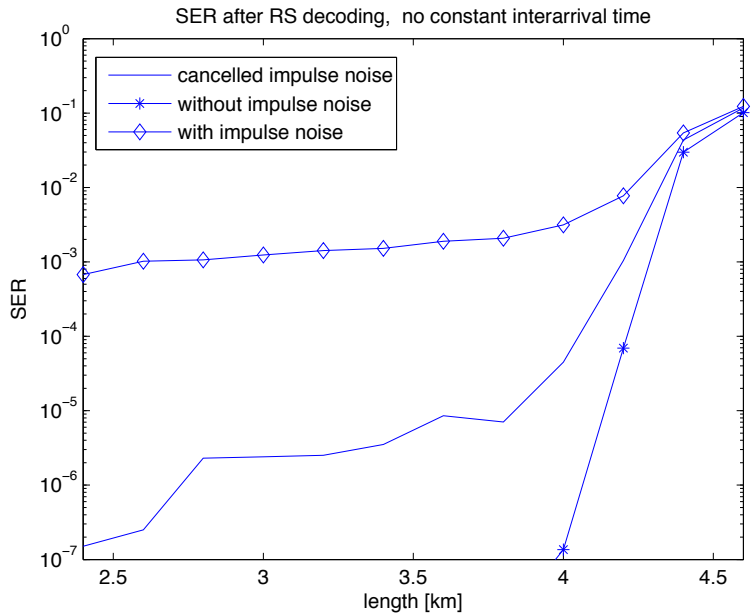
Symbol-error Ratio





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Thank you! Questions?