Improved Error Localization in DSL Systems Based on the Common-Mode

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Overview

- DM and CM signals
- Impulse Noise
- Error and Erasure Coding
- Erasure Marking Approach
  - Impulse Noise Estimation
  - Carrier Marking
- Results

Differential-Mode vs. Common-Mode

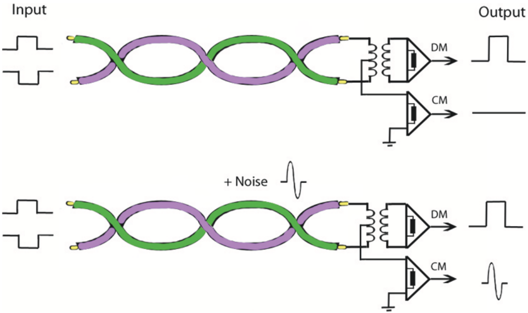

Figure 1: DM vs. CM signaling. Here, square pulses have been used for illustrative purposes, which is not the case in practical situations. For simulations an ADSL transmission system as described in [1] has been employed.

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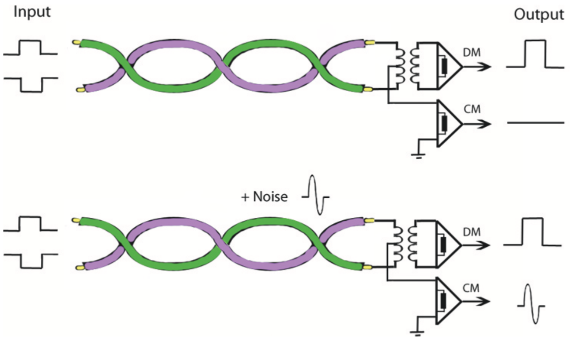

DM:

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

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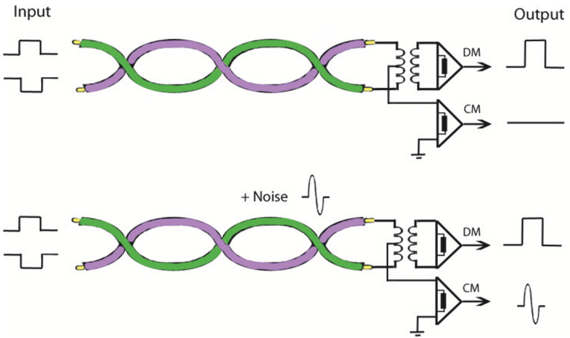

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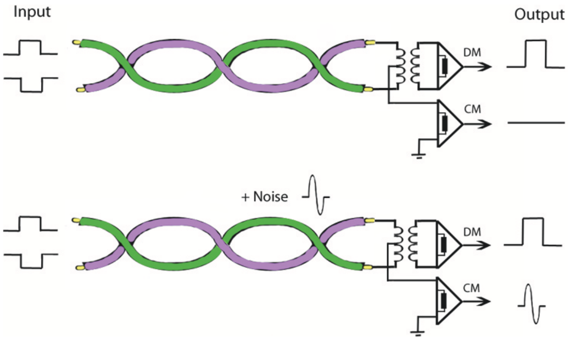

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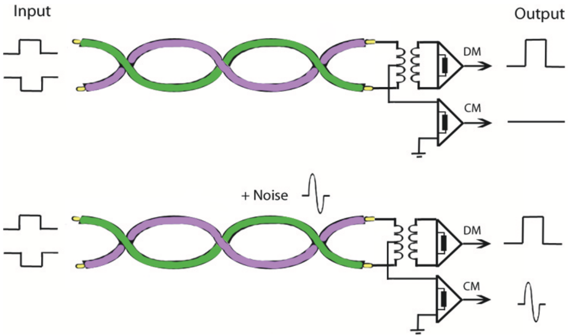

CM:

- arithmetic mean of the two signals measured with respect to ground
- used as reference signal for interference
- measured at center tap of a balun

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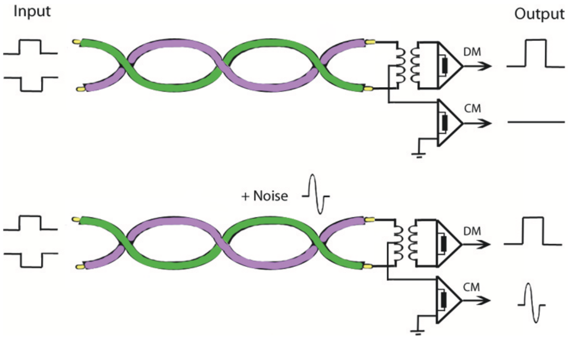

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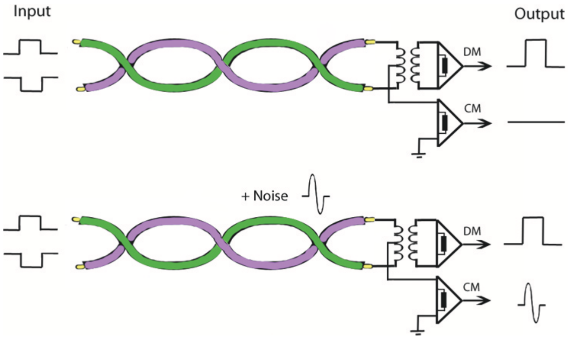

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Impulse Noise

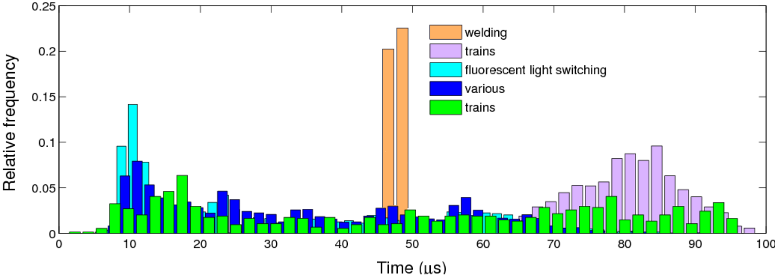


Figure 2: Normalized histograms of impulse duration. The sets of impulses were measured in different locations in Bremen, Germany, and were caused by various sources, e.g., welding, fluorescent light switching, etc.

Inter-arrival Time Distribution

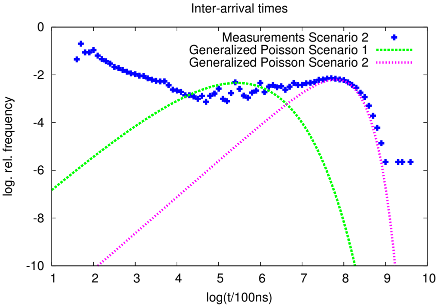


Figure 3: Logarithmic plot of impulse inter-arrival time approximated by a generalized Poisson distribution [2, 3, 4, 5] with parameters detailed in Table 1.

Generalized Poisson Distribution

$$f_d(x) = \frac{10^{a_1}}{\ln(10)} x^{a_4 - 1} 10^{-\frac{a_4}{\ln(a_2)} a_2^{\log_{10}(x) - a_3}}$$

Inter-arrival parameters

Case	a_1	a_2	a_3	a_4	x
#1	-7.54	1.88	5.44	1.52	t/100 ns
#2	-12.54	5.88	7.8	1.52	t/100 ns

Table 1: Both scenarios are obtained from sets of measurements taken in Germany. First scenario is at a central office and second scenario is at customer premises.

DM-CM Correlation

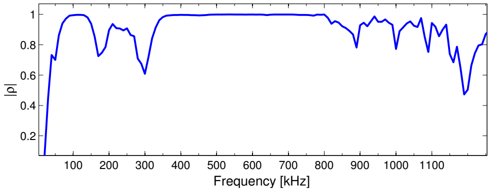


Figure 4: Frequency dependent correlation coefficient between DM and CM for the ADSL range.

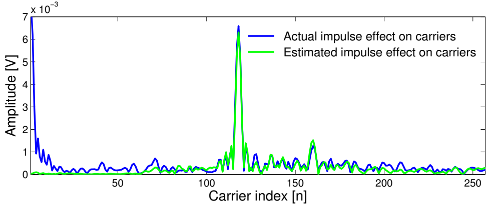


Figure 5: Carriers corrupted by impulse noise obtained from measurements and estimated impulse.

Proposed System Diagram

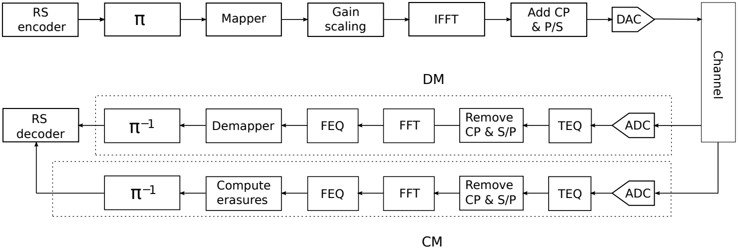
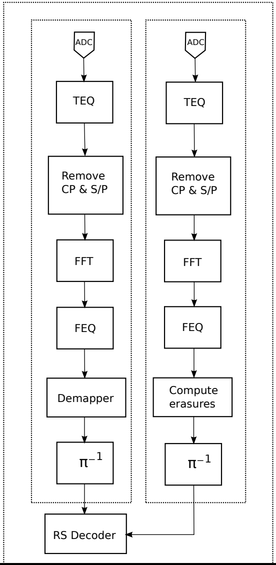


Figure 6: Proposed system diagram. No changes are necessary at the transmitter side. At the receiver side, joint DM-CM processing is performed.

Proposed Algorithm

Get *DM* and *CM* signals.
if *CM* $\geq \lambda$ **then**
    activate *erasure marking*
else
    set deinterleaver erasure matrix to zero
    proceed without using the CM signal
end if
while *erasure marking* activated **do**
    obtain impulse noise estimate
    for both *DM* and *estimate* **do**
        pass through TEQ
        remove guard interval
        perform FFT
        perform frequency domain equalization
    end for
    pass *DM* to demapper
    if *estimate* $\geq \tau$ **then**
        get vector $\boldsymbol{u}$ of corrupted carrier indices
        for every position in $\boldsymbol{u}$ **do**
            determine corrupted bits given bit allocation table
            mark possibly corrupted bits as erasures
        end for
        build deinterleaver erasure matrix
    end if
    build deinterleaver error matrix
end while
perform RS decoding



Impulse Noise Estimation

Common-Mode Conversion Transfer Loss

$$H(jw) = \frac{S_{CM-DM}(jw)}{S_{CM-CM}(jw)} \qquad (1)$$

Impulse Estimate

$$\hat{I}_{dm}(jw) = I_{cm}(jw)H(jw) \qquad (2)$$

Erasure Marking

$$s + 2(e - v) \leq 2t = n - k \qquad (3)$$

s =	number of erasures
e =	number of errors
v =	number of erasures and errors that overlap
t =	error correcting capability of the code

Carrier Marking

- Scenario 1: constant threshold $\tau = \eta$ for all carriers
- Scenario 2: carrier-adaptive threshold $\tau[i]$

$$\tau[i] = \eta \frac{\sqrt{(S_{CM} + N_{CM})\frac{S_{DM}}{S_{CM}}}}{\sqrt{S_{DM} + N_{DM}}} \qquad (4)$$

$$\tau[i] = \eta \sqrt{\frac{\frac{S_{DM}[i]}{S_{CM}[i]}}{\frac{S_{DM}[i]+N_{DM}[i]}{S_{CM}[i]+N_{CM}[i]}}} \qquad (5)$$

where $|H|^2 = \frac{S_{DM}}{S_{CM}}$.

$S_{CM-DM}(jw)$ =	average pseudo cross PSD of DM
$S_{CM-DM}(jw)$ =	average pseudo PSD of CM
$N_{DM}(jw)$ =	noise pseudo PSD in DM
$N_{CM}(jw)$ =	noise pseudo PSD in CM

Simulation Parameters

Table: G.996 ADSL Simulation Parameters

Reed Solomon (RS) Code Parameters	
Interleaver depth *d*	32
DMT symbols in RS codeword *s*	2
Information symbols *k* in RS codeword	134
Error correcting capability *t*	6
RS symbol size	8 bits
DMT Downstream [a] Parameters	
AWGN	-120 dBm/Hz
Number of carriers	254
Downstream net rate	2.048 Mbit/s
Reserved carriers	0–5, 96
Carrier spacing	4.3125 kHz
Cable diameter	4 mm
Transmit power	20 dBm
Sampling rate	2.208 MHz
Loop range	2.6 - 4.6 km
Cyclic prefix	32 samples
Number of NEXT disturbers [b]	4 AslMx

[a] Simulations were performed for downstream only.

[b] FEXT effect is considered negligible.

Results

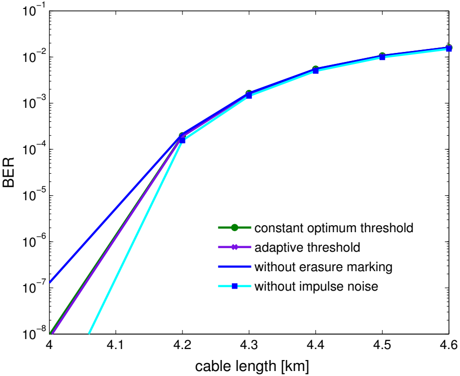


Figure 7: BER after RS decoding for the slightly impulsive environment. As expected, when the main interference source is AWGN and no other stronger interferers are present, the improvement obtained by employing the erasure scheme is not very significant.

Results

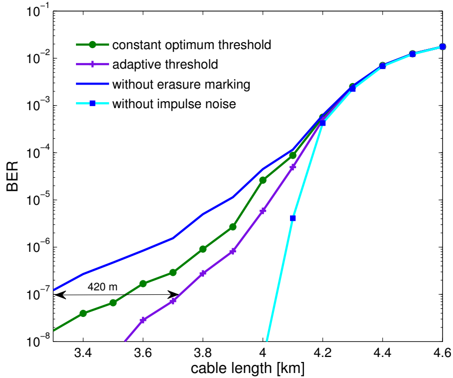


Figure 8: BER after RS decoding for the highly impulsive environment. The proposed erasure marking scheme has a significant gain when presented with a strongly impulsive case.

Thank you!

References

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