

IEEE 802.3ah - EFM over Point-to-Point Copper

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Ethernet in the First Mile  
Point-to-Point Copper Track  
Copenhagen, 17-19 September 2001

Specification of Public Access Networks (Part I)

prepared by Michael Beck (Alcatel)

# Supporters

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### ◆ Goals:

1. Define a set of loops, representative of public access networks, on which all EFMC proposals can be simulated and/or tested.
2. Define a set of crosstalkers and noise sources, representative of public access networks, which shall be applied in the simulations/tests of all EFMC proposals.

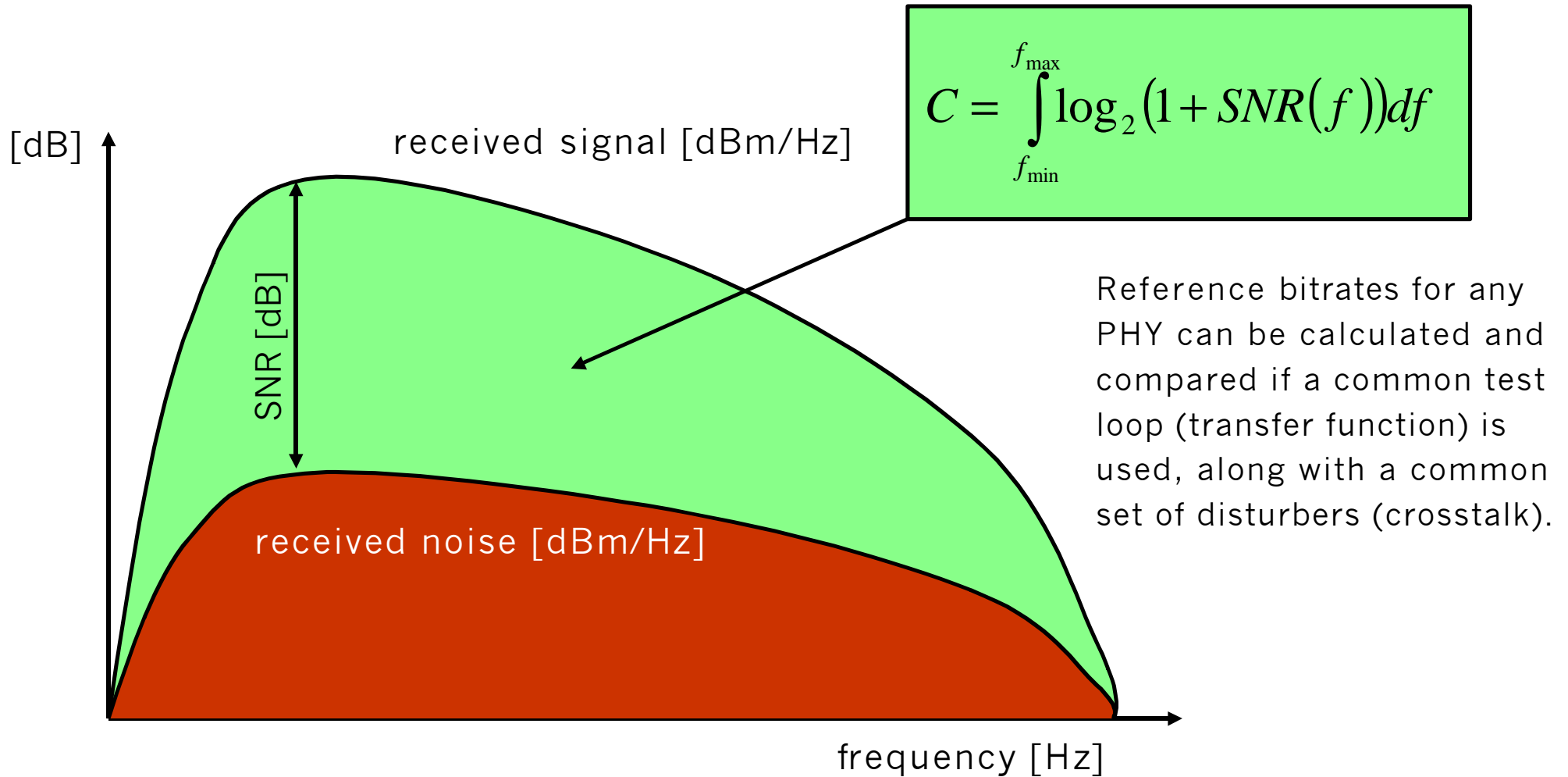
### ◆ This presentation...

- ...is a status report of the work that has been going on off-line in the EFM/Copper group
- ...does **not** answer all the questions raised by the above goals. We are waiting for **your input** to finish this job!

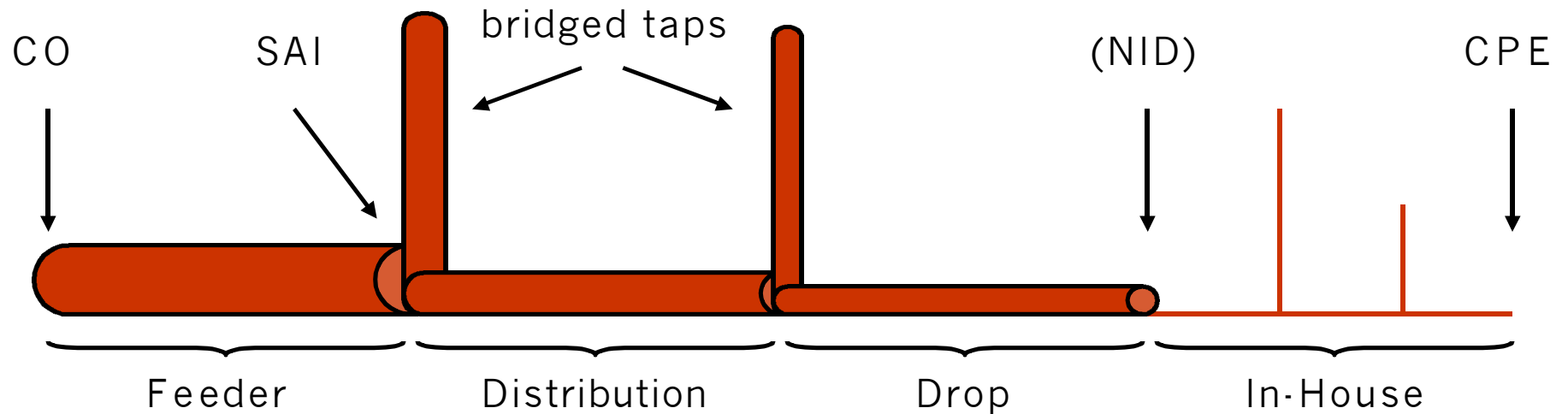
- ◆ Use of Test Loops and Crosstalkers
- ◆ Topology of the Public Access Network
- ◆ Cable Types and Models
- ◆ Region-specific Information: **Europe**
- ◆ Region-specific Information: **North America**
- ◆ Region-specific Information: **Asia**
- ◆ Region-specific Information: **Rest of World**
- ◆ EMI
- ◆ Conclusions

# Overview

## Use of Test Loops and Crosstalkers



# Topology of the Public Access Network Introduction



<ul style="list-style-type: none"> <li>•up to 4200 pairs per cable</li> </ul> <p>finer gauge</p>	<ul style="list-style-type: none"> <li>•up to 4200 pairs per cable</li> <li>•bridged taps common in some regions</li> </ul>	<ul style="list-style-type: none"> <li>•aerial/buried</li> <li>•1-100s of pairs</li> <li>•18-24 gauge</li> <li>•short wires may be untwisted pair!</li> <li>•bridged taps common in some regions</li> </ul>	<ul style="list-style-type: none"> <li>•small number of pairs</li> <li>•24-26 gauge</li> <li>•twisted/untwisted</li> <li>•bridged taps common</li> <li>•owned and managed by the customer!</li> </ul> <p>coarser gauge</p>
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# Topology of the Public Access Network

## Statistical Data

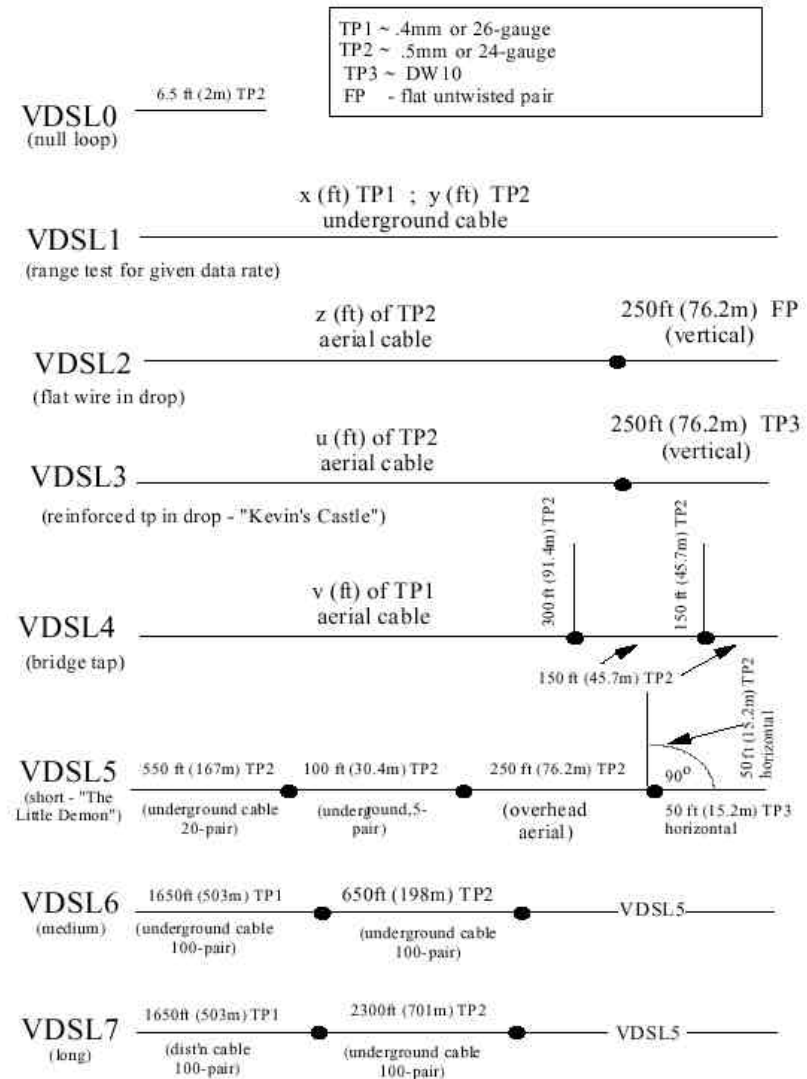
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- ◆ Actual parameters describing the subscriber loop topology may vary between regions as well as within a single region.
- ◆ For the US, some (old) statistics are available:
  - mean working length (non loaded loops) =  $7535 \pm 116$  ft.
  - mean bridged tap length (non loaded loops) =  $1168 \pm 35$  ft.
  - mean resistance (working pairs) =  $644 \pm 8$  Ohms
  - awg distrib.: 19: 2.7% / 22: 21.3% / 24: 35.6% / 26: 40.4%

# Topology of the Public Access Network Test Loops

The topological statistics of the public access networks of different regions can be summarized in a set of representative “test loops”.

- ◆ T1E1.4/2001-009 contains eight test loop topologies (shown right), representing a subset of North American subscriber lines that may be used to offer VDSL services.
- ◆ ETSI TS 101 270-1 contains similar loops for use in Europe (no bridged taps).
- ◆ PN 4254-INT contains several test loops with lengths up to 18.5kft. However, the models in this document are for use below 1.104MHz only.



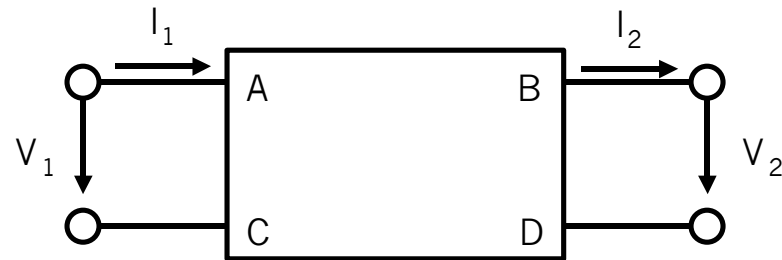


# Cable Types and Models

## Loop Modelling

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- ◆ Models are used to predict the behavior of a set of cable parameters (e.g.  $\{Z_s, Y_p\}$  or  $\{Z_0, \gamma\}$ ) over a certain frequency range, based on physical or empirical constants.
- ◆ Any loop section can be represented by an ABCD-matrix derived from these parameters.
- ◆ Complex loop systems can be described by a cascade of such matrices.



Generic Two-Port Network

## Region-specific Information: **North America**

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- ◆ American National Standard T1.417 (Annex B) provides cable (model) parameters for various kinds of (twisted) pairs:
  - **26 awg**
    - 26 awg PIC air core
    - 26 awg filled PIC
  - **24 awg**
    - 24 awg PIC air core
  - **22 awg**
    - 22 awg PIC air core
  - **FP**, 1.14mm flat cable (model parameters and primary constants only)
  - **Category 5** (model parameters and primary constants only)
  - **Drops**
    - two-pair twisted drop
    - two-pair quad drop
    - flat-pair drop

## Region-specific Information: **Europe**

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- ◆ ETSI/STC TM6(97)02: Two-port line constants are available for over 30 types of access cables, in use in following countries:
  - United Kingdom (British Telecom)
  - France (France Telecom)
  - Germany (Deutsche Telekom AG)
  - The Netherlands (KPN)
  - Finland and Baltic countries (Nokia)
  - Switzerland (Swisscom)

## Region-specific Information: **Asia**

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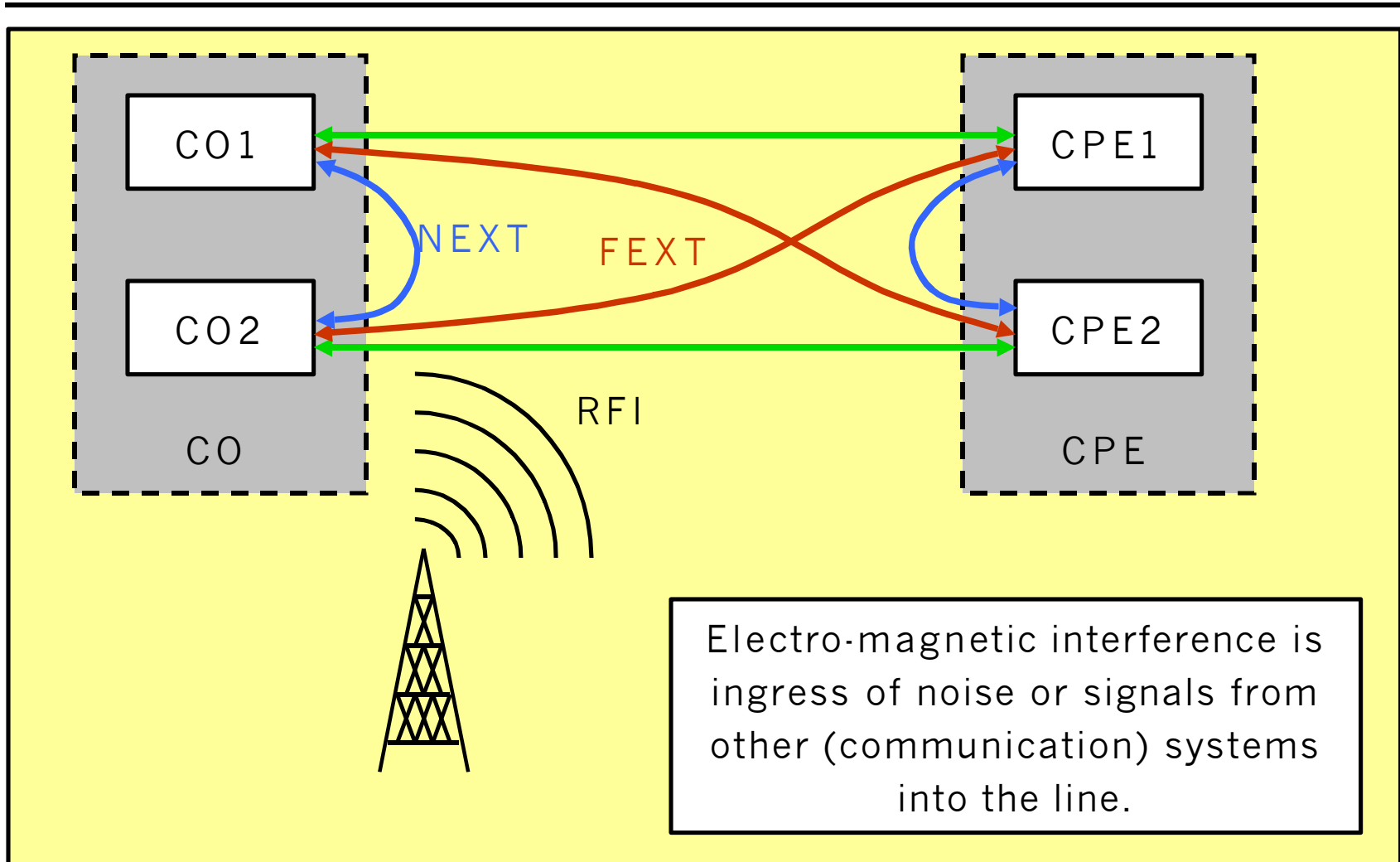
- ◆ Currently available information covers only Korea and Taiwan.
  - Korea: copper cables in distribution cabling section in Korea show poorer crosstalk performance than ETSI (BTdwug) cable and ANSI cables.
  - Taiwan: *<to be completed>*

## Region-specific Information: **Rest of World**

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◆ *To be completed.*

# EMI Introduction



## Modelling the Crosstalk Coupling Function

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- ◆ In order to assess the influence of other systems in the loop plant on the DUT, the crosstalk coupling function must be known. Following crosstalk models for single loop segments are most often used:

- Power-summed crosstalk models X#0 (ETSI, ANSI)

- NEXT:  $|s_{xn}(N, \mathbf{w})| \approx \Phi(N) \cdot K_{xn} \cdot (\mathbf{w}/\mathbf{w}_0)^{K_w}$

- FEXT:  $|s_{xf}(N, \mathbf{w})| \approx \Phi(N) \cdot K_{xf} \cdot (\mathbf{w}/\mathbf{w}_0) \cdot (x/x_0)^{K_L} \cdot S_{T0}$

- Power-summed crosstalk models X#1 (ETSI)

- NEXT:  $|s_{xn}(N, \mathbf{w}, x)| \approx \Phi(N) \times \frac{\mathbf{w} \cdot R_N \cdot C_{xxn}}{2 \cdot \sqrt{\mathbf{a}}} \times \sqrt{1 - (S_{T0})^4}$

- FEXT:  $|s_{xf}(N, \mathbf{w}, x)| \approx \Phi(N) \times \frac{\mathbf{w} \cdot R_N \cdot C_{xf}}{2} \times (x/x_0)^{K_L} \times S_{T0}$

## EMI Disturbers

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- ◆ SELF crosstalk is the noise introduced by similar systems as the system under test, at both ends of the line.
- ◆ ALIEN crosstalk is the noise introduced by other systems deployed in the loop plant; these may include the basis systems mentioned in T1.417 (ISDN, ADSL, HDSL, ...), new standardized systems (SHDSL, VDSL) and proprietary systems.
- ◆ RFI is noise that radiates into the line from outside the cable (e.g. AM radio broadcast).
- ◆ A “typical” selection of disturbers for evaluation purposes should at least contain SELF crosstalk, RFI, region-dependent broadband transmission systems (e.g. VDSL-998 in North America), and a (possibly region-dependent) mix of alien crosstalkers below 1.1MHz (e.g. ISDN, ADSL).



## Conclusions (1)

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- ◆ Following test loops are being proposed for simulation of the performance of EFMC PHY proposals (for discussion):
  - **North America:** TBD subset of test loops defined in T1E1.4/2001-009
  - **Europe:** TBD subset of test loops defined in ETSI TS101 270-1
  - **Asia:** TBD
  - **Rest of World:** TBD
- ◆ The set of noise sources should include SELF-crosstalk, RFI, and a region-dependent set of alien crosstalkers.

◆ Motion:

“The IEEE 802.3ah task force shall define a set of test loops and noise sources, representative of subscriber access networks, on which all PHY-proposals for EFM over point-to-point copper shall be evaluated.”

# References

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-  Bell Communications Research, Characterization of Subscriber Loops for Voice and ISDN Services, 1983
-  ETSI/STC TM6(97)02: Cable reference models for simulating metallic access networks
-  ETSI TS101 270-1: VDSL; Part 1: Functional Requirements
-  ITU-T SG15 TD NT-062R1: Reference Cable model for VDSL in Korea (Korea Telecom)
-  JSAC, August 1991 (Taiwan)
-  PN-4254-INT Draft 1, International Network Access transmission Model for evaluating xDSL Performnace
-  T1.417: Spectrum Management for Loop Transmission Systems
-  T1E1.4/2001-009: Draft VDSL Standard, Part I