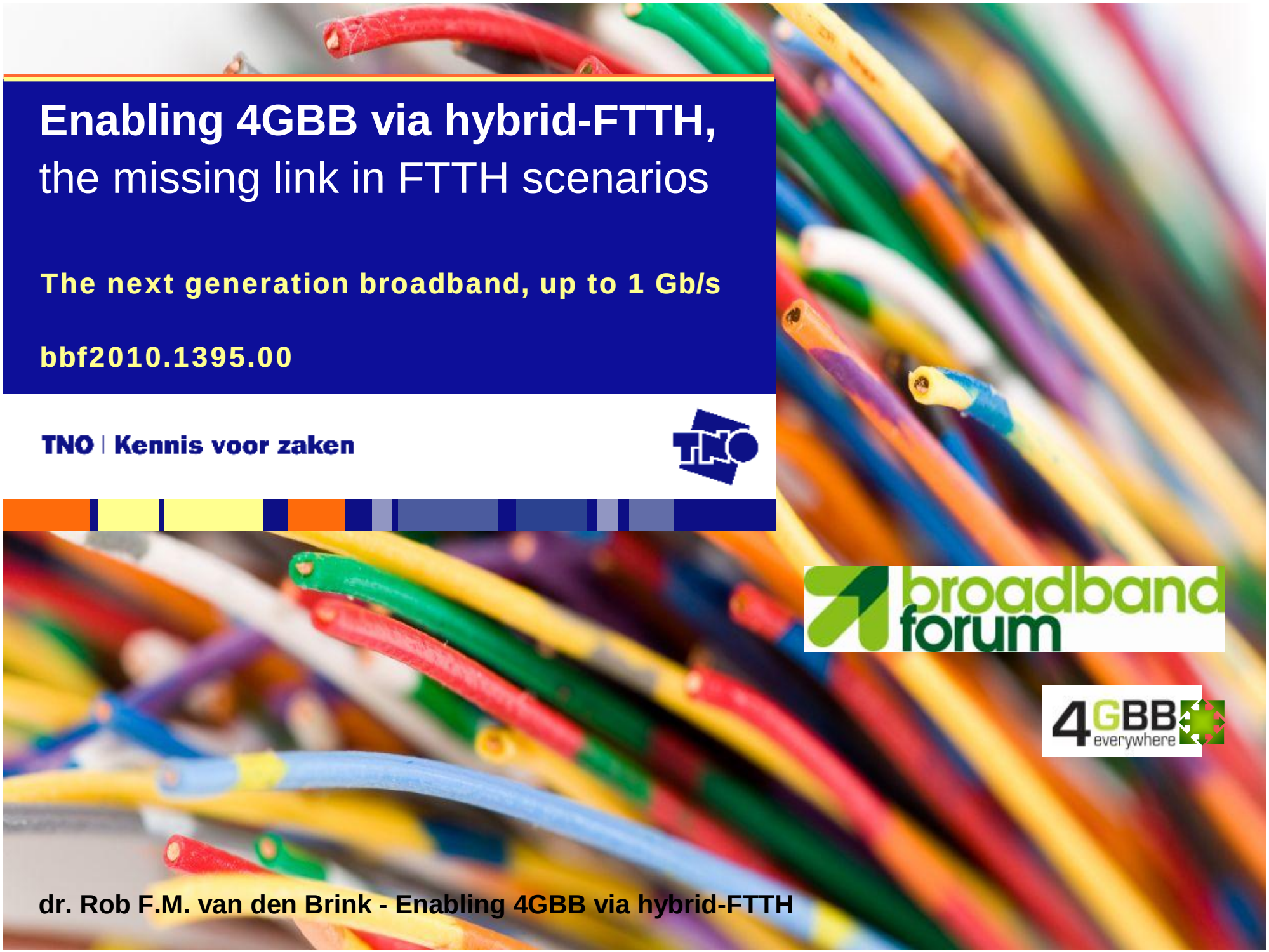
Enabling 4GBB via hybrid-FTTH,
the missing link in FTTH scenarios

The next generation broadband, up to 1 Gb/s

bbf2010.1395.00

TNO | Kennis voor zaken



dr. Rob F.M. van den Brink - Enabling 4GBB via hybrid-FTTH

1. How to enable broadband? (for Telco's)

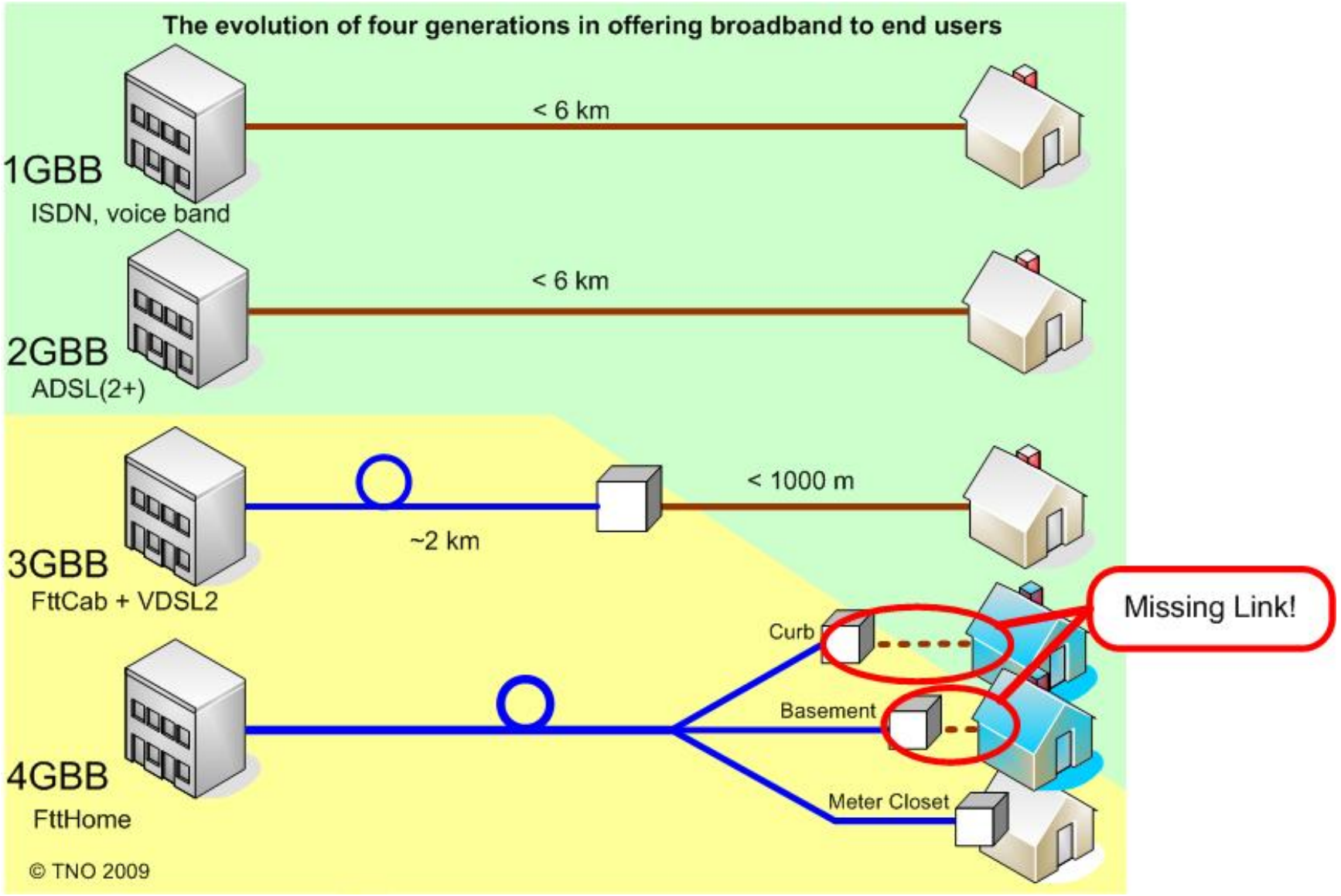
By visionairs à Disruptive

- **Fiber to the Home**
  - 100 – 1000 Mb/s is needed anywhere
  - predicted during the last 25 years

In practice à Gradual grow + different options

- **Narrow band (<33kb/s):**
  - voice band modems
- **1GBB (33k-1Mb/s):**
  - ISDN (NL:1988?)
  - first ADSL subscriptions (NL:1998)
  - first cable modems
- **2GBB (1-10 Mb/s),** Commodity in NL (2009 ≈80% home connections)
  - ADSL2/ADSL2p, HDSL (1995), SDSL(2000) NL: (2010 ≈ 50%)
  - Cable modems (DOCSIS 2.0) NL: (2009 ≈ 30%)
  - *some fiber to the home (<3%)*
- **3GBB (10-100MB/s)**
  - VDSL1(1998/2001), VDSL2(2006) *fiber to the cabinet*
  - Cable modems (DOCSIS 3.0)
  - *more fiber to the home (subscribed, not passed-only or connected-only)*
- **4GBB (100M-1Gb/s):**
  - *many cable links ("cable operators")*
  - *many FttH links ("Telcos")* ß this presentation

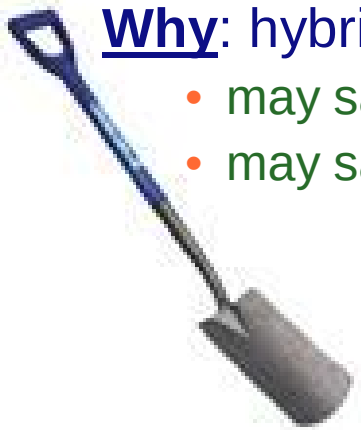
1. How to enable broadband? (for Telco's)



2. Hybrid FttH - complementary to full FttH

FttH is not only fiber beyond the front door

(*hybrid fiber/copper is also possible: Fiber **upto** or **into** the Home*)



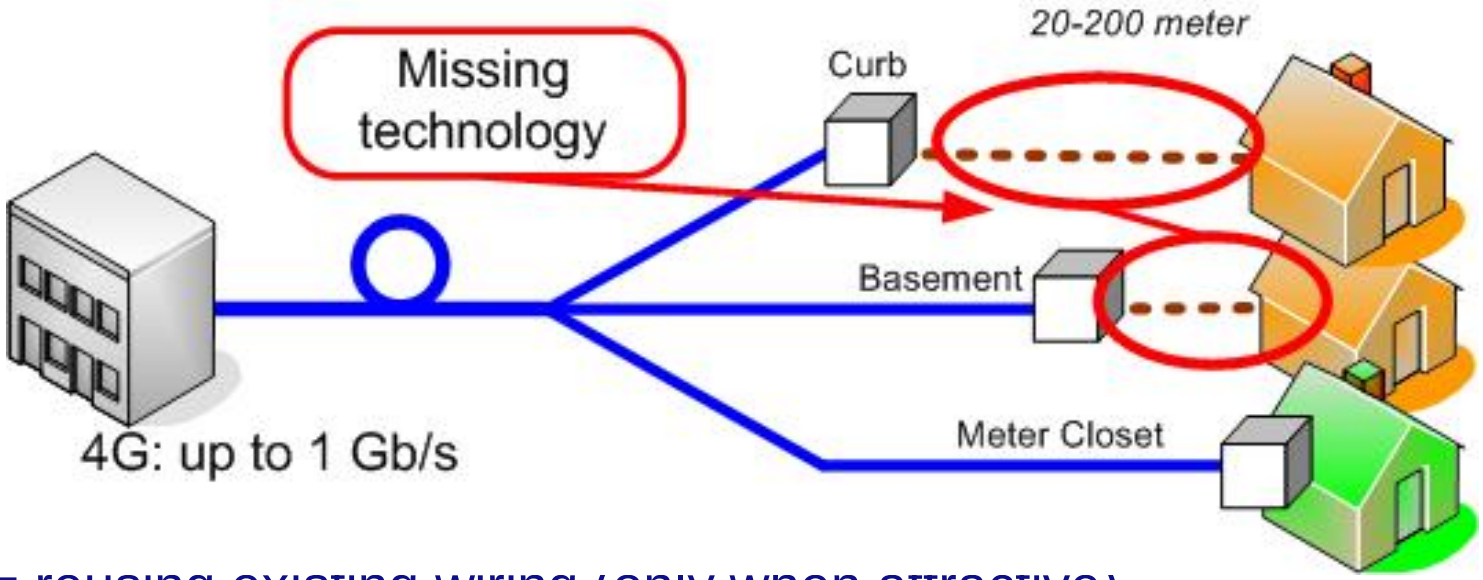
Why: hybrid has possible techno-economic advantages

- may save costs for digging/installation when copper can be reused
- may save installation time, so faster roll-out

Where: possible scenarios

- apartment buildings, multi-tenant houses, city centers
- FttH: 80% beyond the front door? – full fiber
- FttH: 20% up to the basement or curb (footway boxes)? – hybrid fiber
- 20% covers a lot of connections!

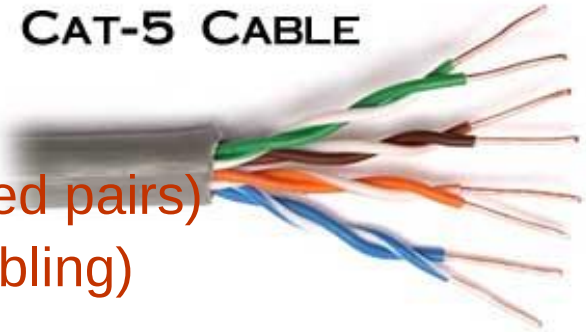
2. Hybrid FttH - complementary to full FttH



- **How:** hybrid = reusing existing wiring (only when attractive)
  - bridging the last 20-200m
  - single wire-pair or (when possible) to bonded wire pairs (*double rate*)
  - up to 1 Gb/s, using a new (ultimate) DSL technology

- **How**: hybrid = distribution points:
  - fiber to multiple copper, and reverse
  - Footway boxes, basement boxes, house front boxes, …
  - Power feeding from meter closets

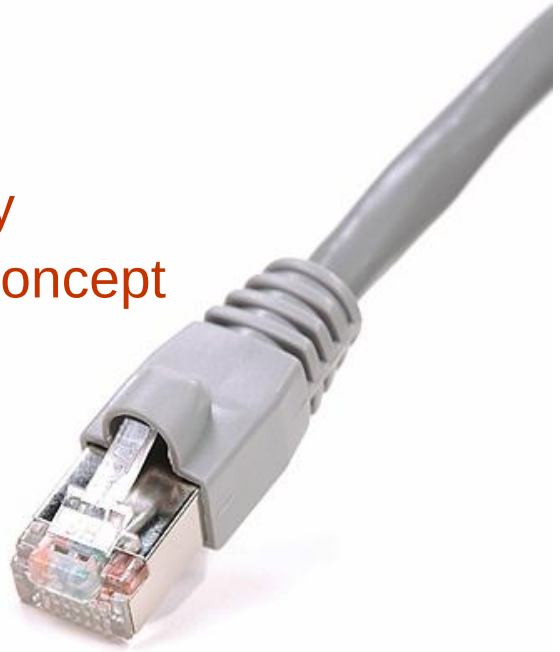
2. Hybrid FttH - is up to 1 Gb/s feasible via copper?



- Today: 1 Gb/s Ethernet via copper (1000 BASE-T)
  - 1 Gb-ethernet is a consumer product (via 4 twisted pairs)
  - 10 Gb-ethernet exists as well (via high quality cabling)

- In progress: more tranceivers up to 1 Gb/s
  - G.hn (home networking tranceivers) up to 1 Gb/s
  - several >>100Mb/s experiments reported by industry
  - 4GBB/CELTIC consortium studies feasibility of the concept

- Topology opportunities
  - the last copper drop can be very short
  - bonding quads is an opportunity in some countries



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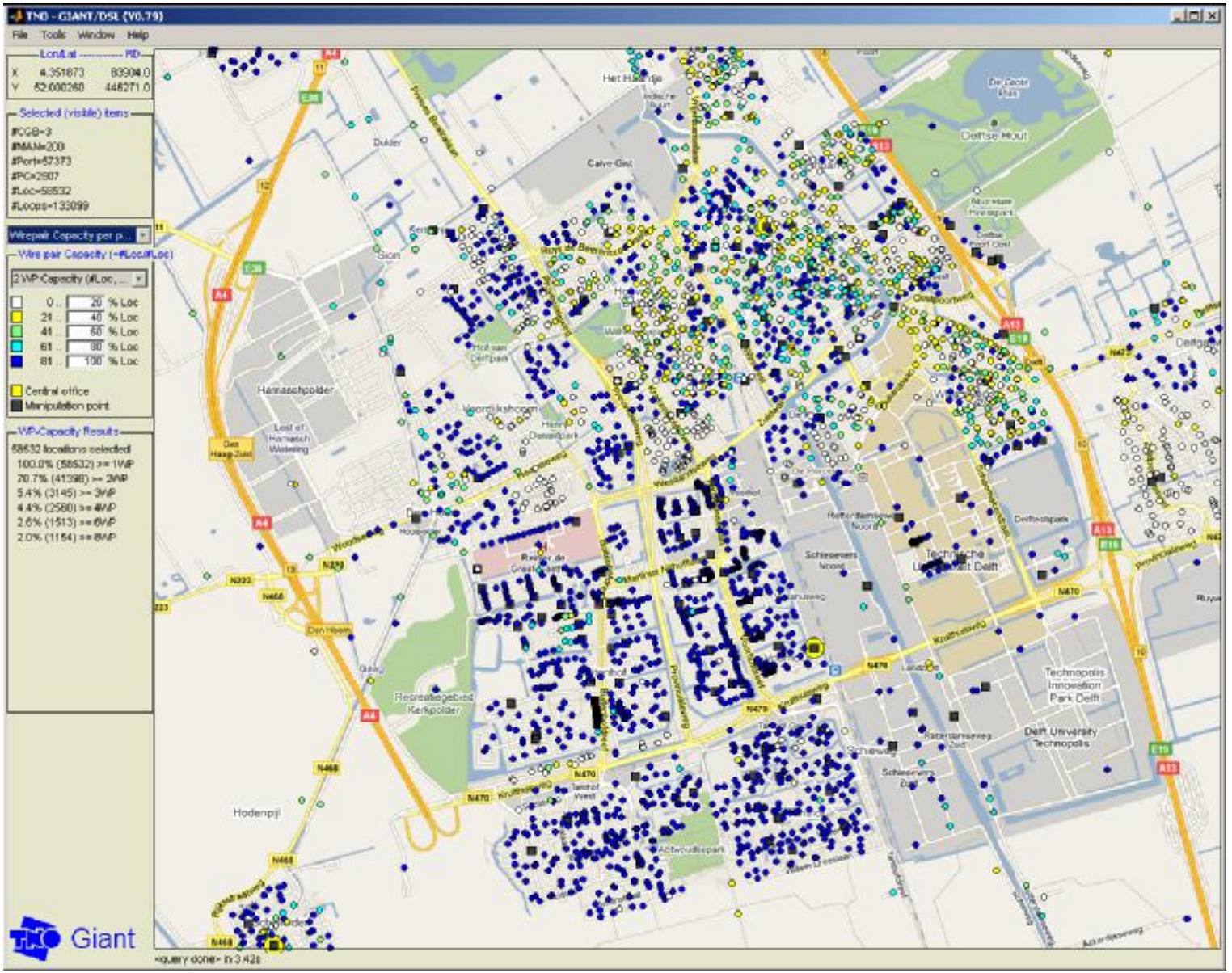
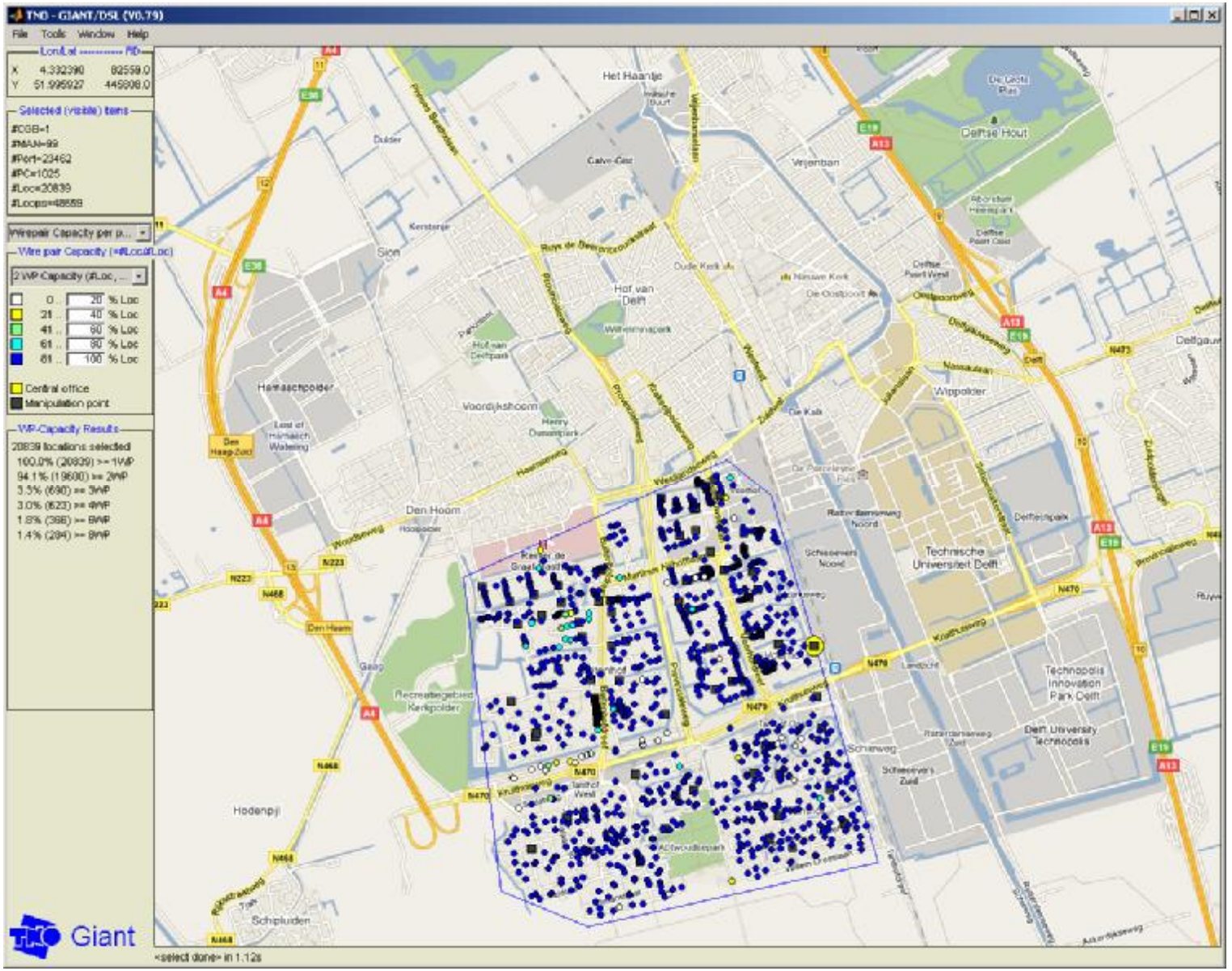


A typical Dutch city

Bold markers denote 80-100% has a double wire pair

>70% in this city (example)

2. Hybrid FttH - is up to 1 Gb/s feasible via copper?



A typical Dutch city

Bold markers denote 80-100% has a double wire pair

>95% in selected areas

2. Hybrid FttH - is up to 1 Gb/s feasible via copper?

Many questions to be solved

Is it technically feasible via **multi-wire** telephony cabling?

- Cable measurements up to 500MHz
- Noise measurements (impulses, RFI) in operational networks
- modeling, simulation, bitrate predictions
- new transmission technologies (bitrate, MIMO, remotely powered, ..)

• Is it economically attractive?

- Geographic statistics of network topologies
- when using “hybrid fiber/copper”, when “full fiber”

• Will it be available in time?

- should initiate a standard.
- communication toward standardization bodies **Via BBF -> ITU**

à European consortium: “Enabling 4GGB”, (2009-2011)

Members of 4GBB/CELTIC Consortium (2009-2011)

CELTIC
Telecommunication Solutions

EUREKA

ERICSSON

TNO

Telefónica

BT

france telecom R&D

Actelis Networks

SIDSA

TÜRK TELEKOM

upZide

robotiker tecnalia

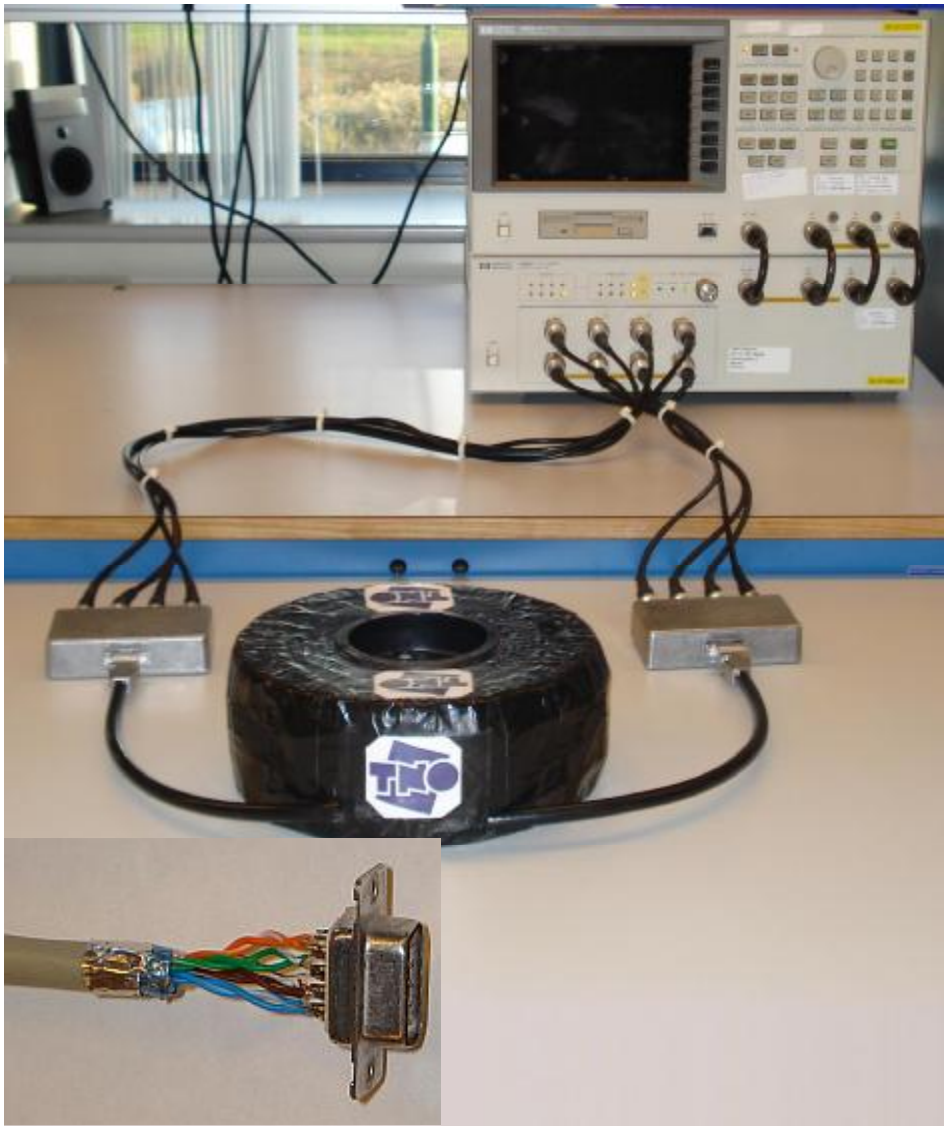
LUNDS UNIVERSITET

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

THE UNIVERSITY OF EDINBURGH

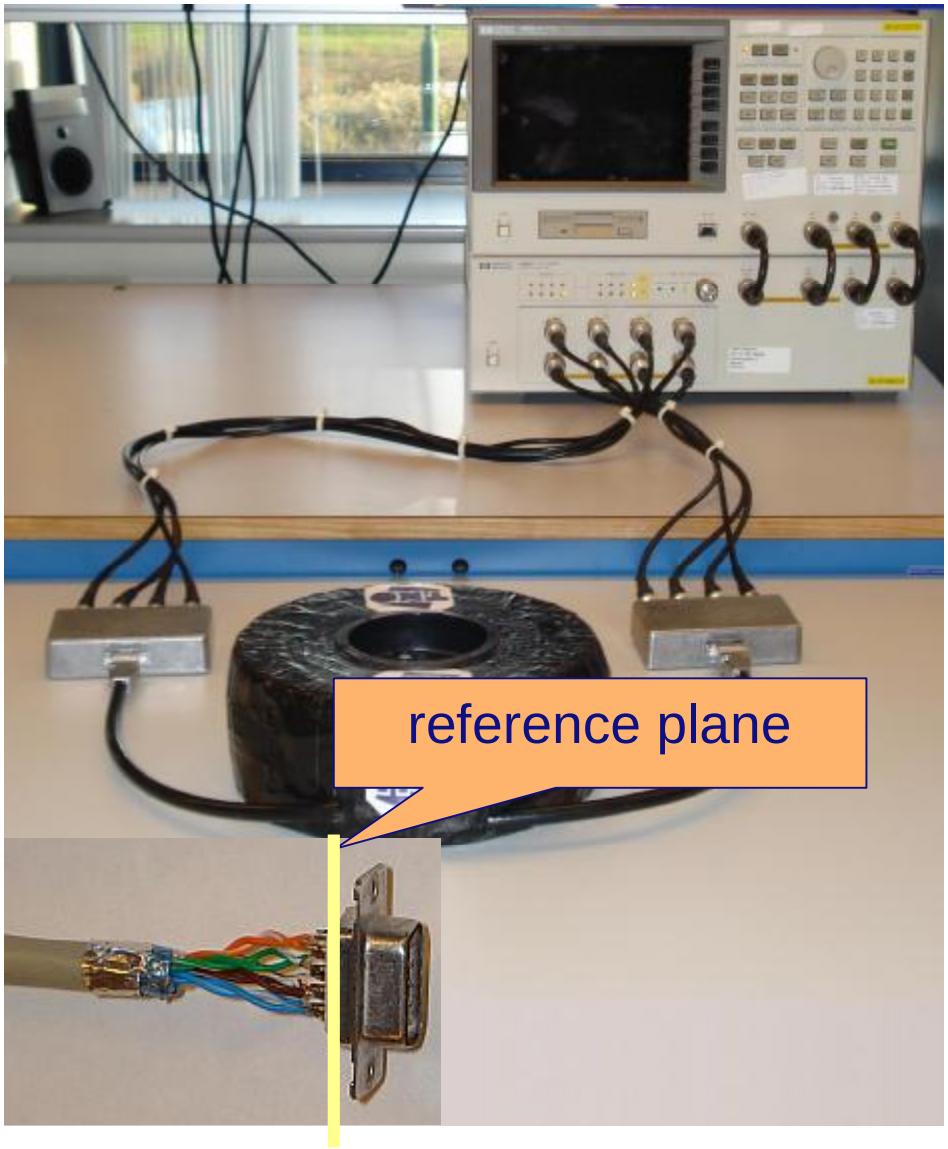
POLITÉCNICA
Ingeniamos el futuro

3. Multiport cable measurement setup, up to 500 MHz



Measurement setup

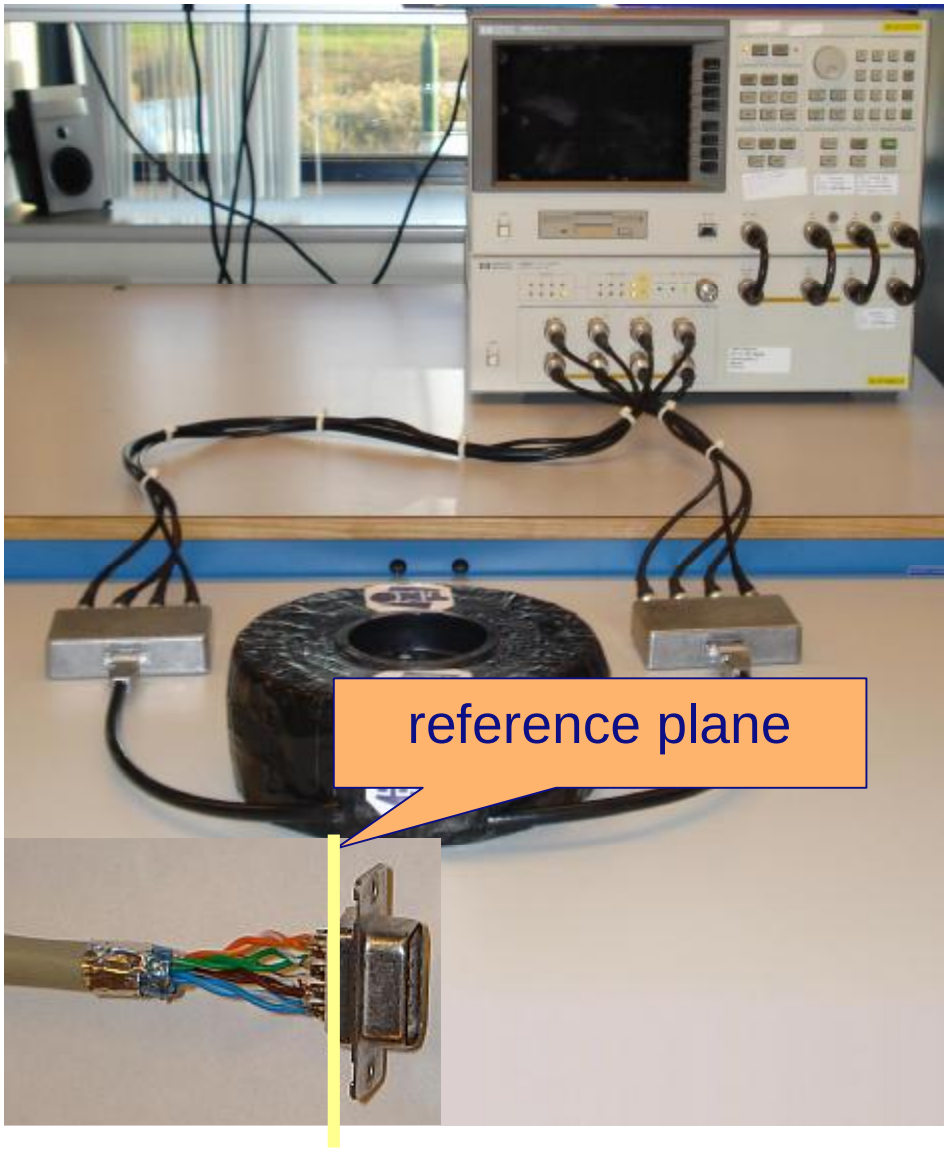
3. Multiport cable measurement setup, up to 500 MHz



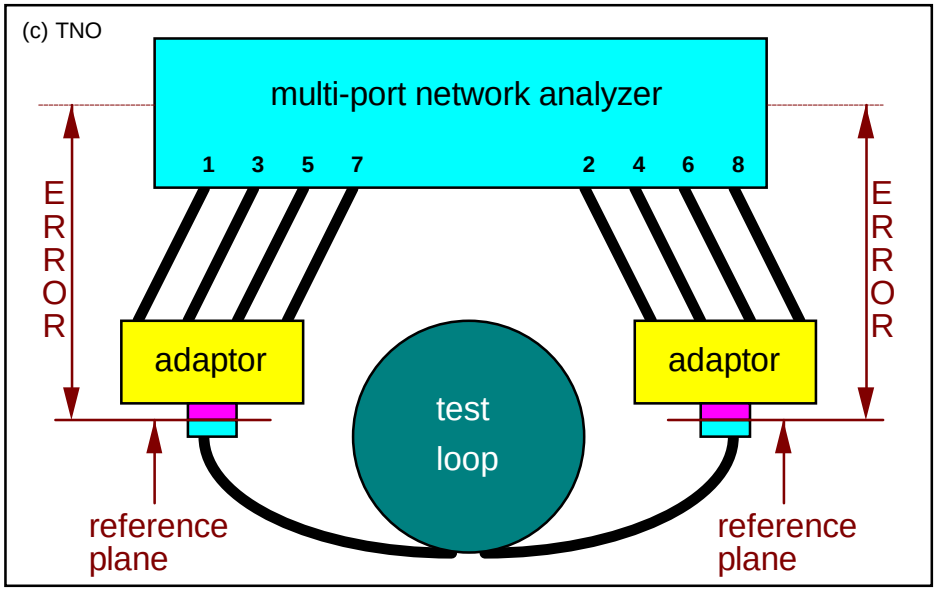
Measurement setup

Key problem:
Instrument does not measure what I would like to know!

3. Multiport cable measurement setup, up to 500 MHz

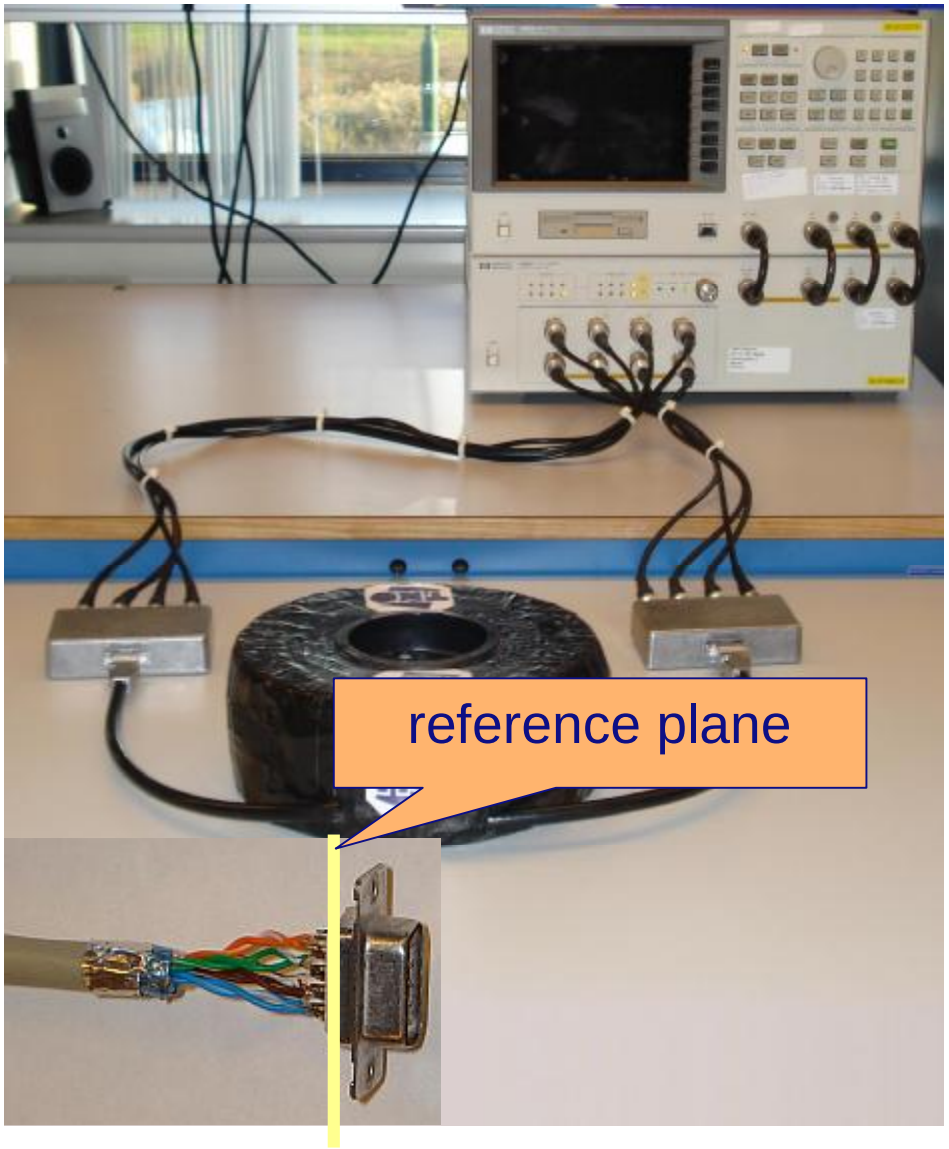


Measurement setup



schematic diagram

3. Multiport cable measurement setup, up to 500 MHz



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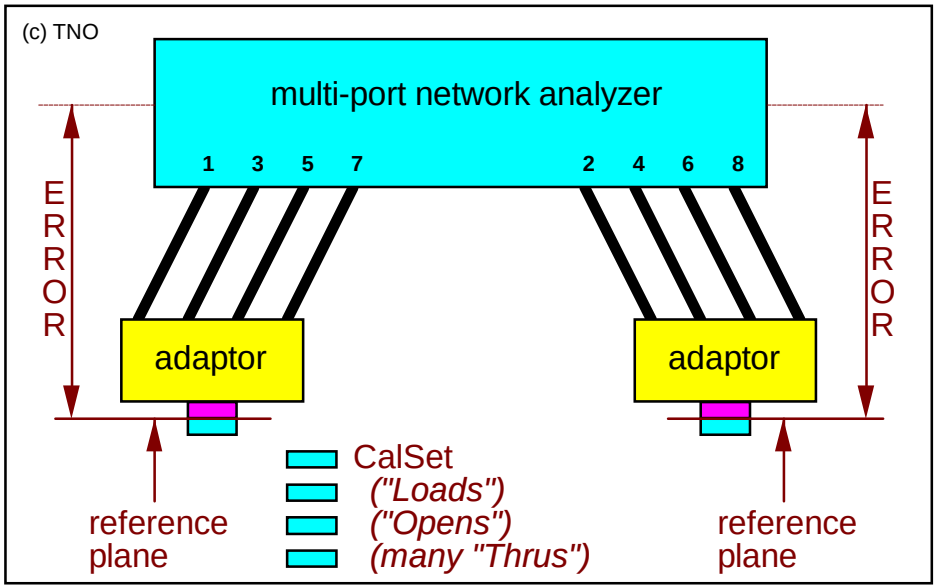
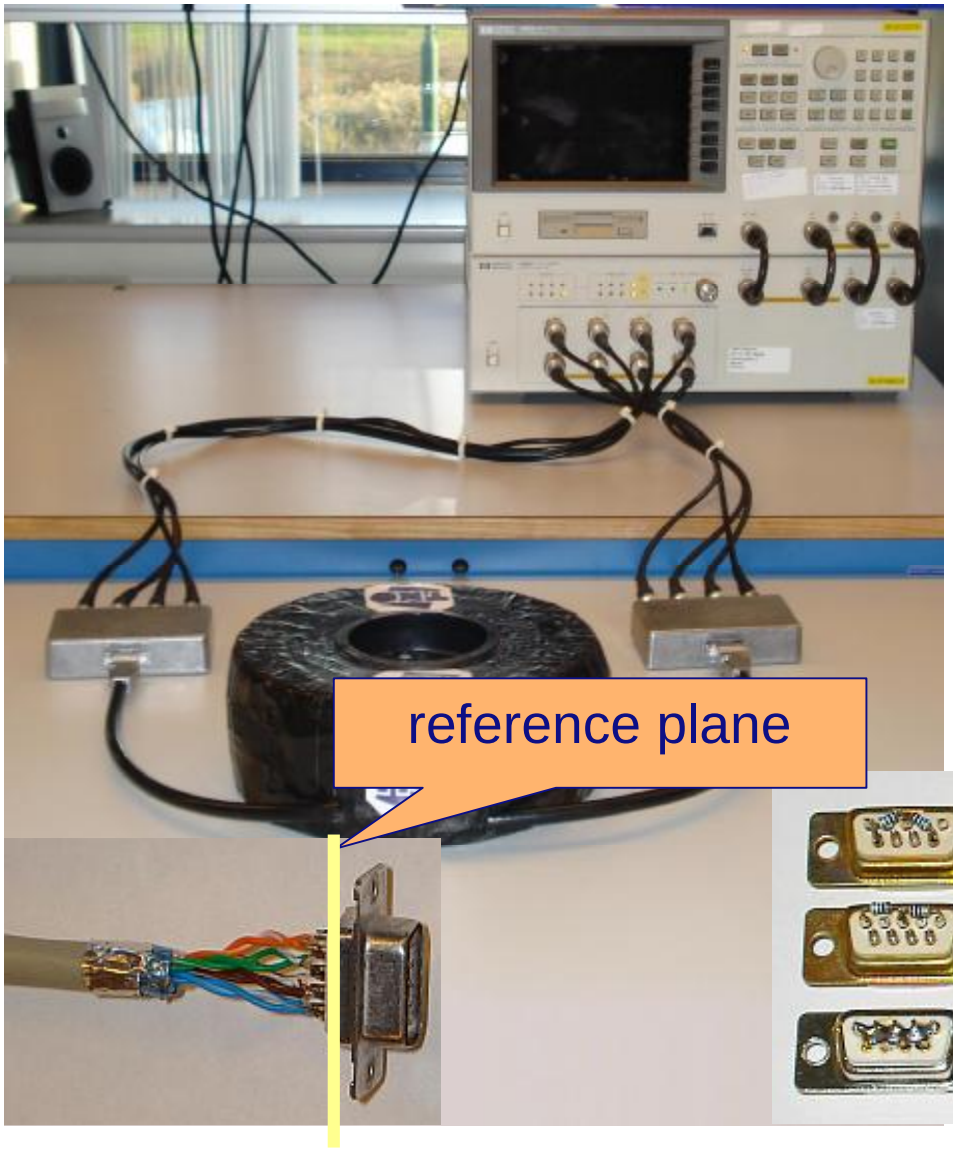
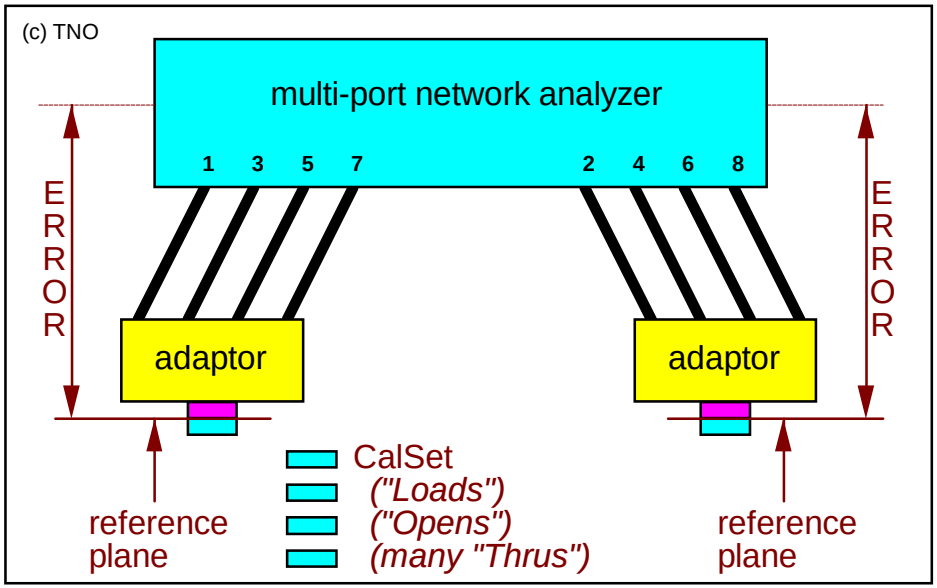


use known networks to measure the errors, and to correct for it via software post-processing …

solve 140 equations to find 48 unknown (for each frequency)

3. Multiport cable measurement setup, up to 500 MHz



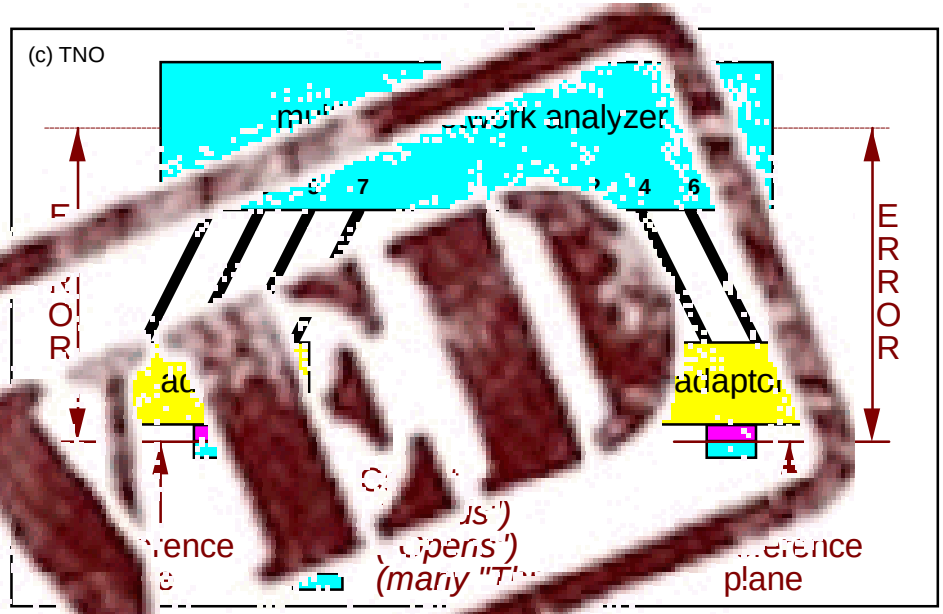


use known networks ….

Measurement setup

calibration set, for error correction

3. Multiport cable measurement setup, up to 500 MHz



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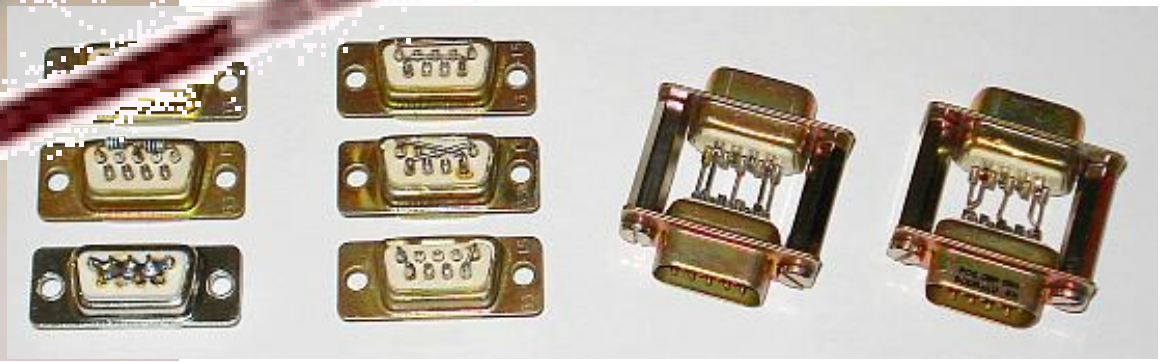
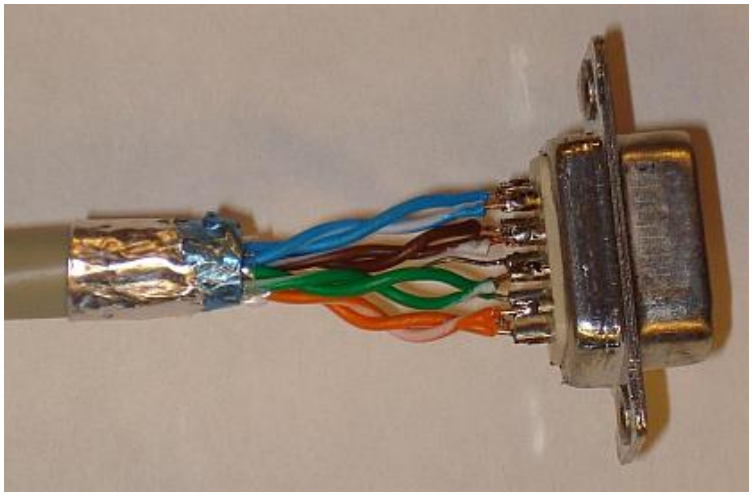


Measurement setup

calibration set, for error correction

4. Characterizing high quality cables (CAT5)

- CAT5-quality
- 4 twisted-pairs
- shielded
- intended for Gb Ethernet networks



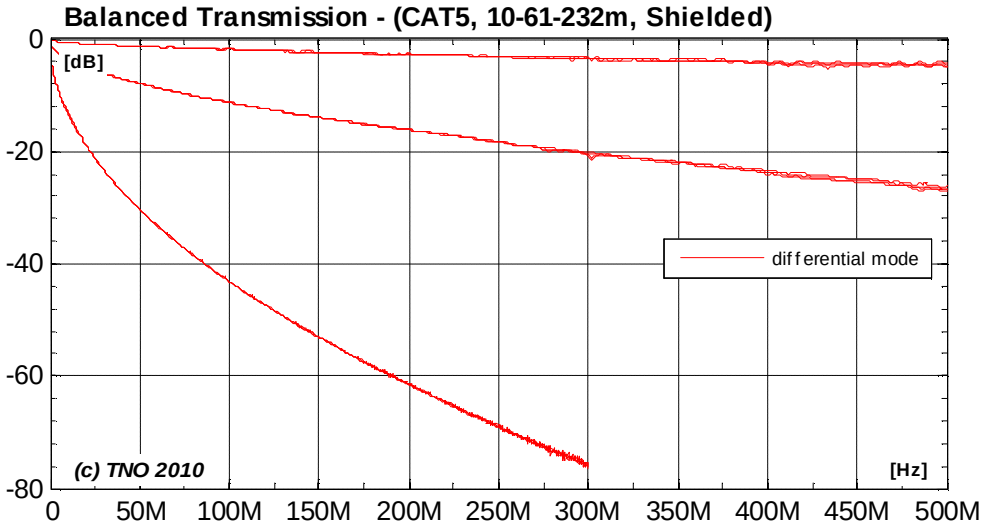
232m, CAT5, 4 twisted-pairs

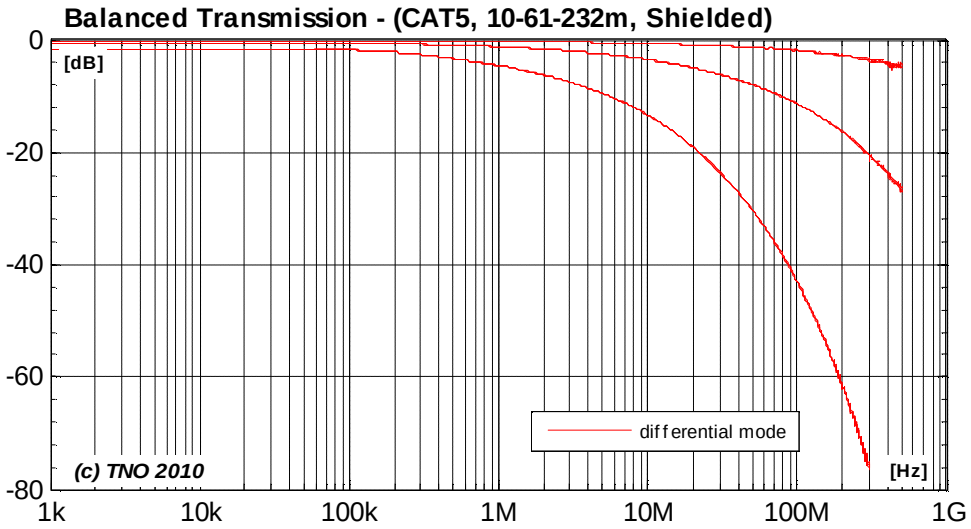
61m, CAT5, 4 twisted-pairs

4. Characterizing high quality cables (CAT5)

Balanced Transmission:

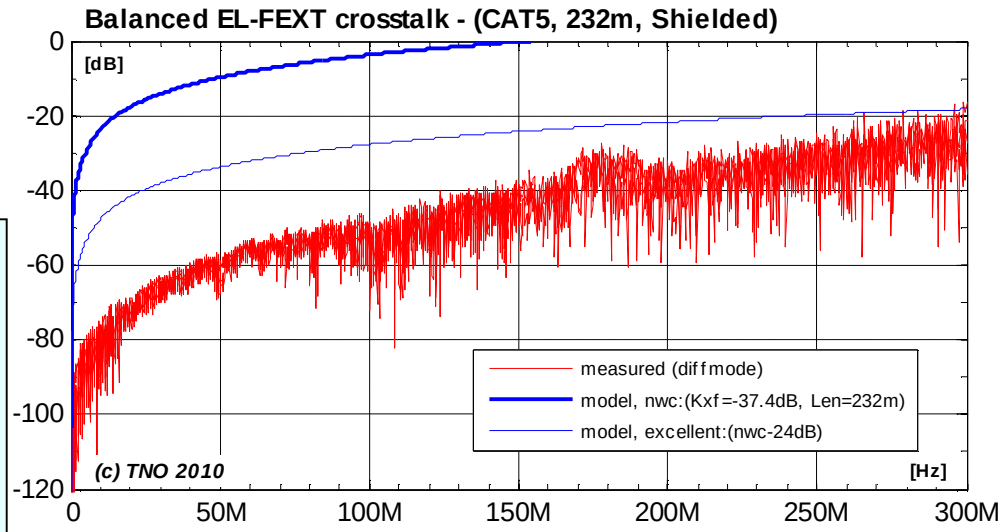
5.7 dB / 100m @ 10MHz
18.6 dB / 100m @ 100MHz





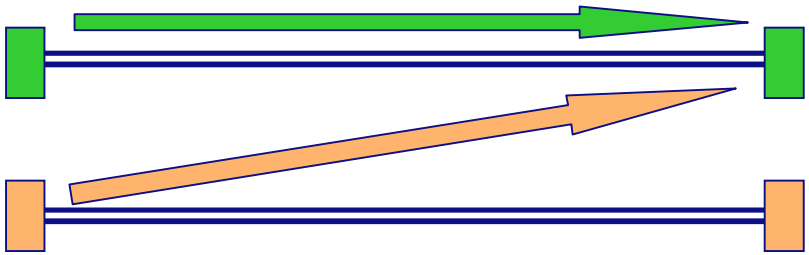
4. Characterizing high quality cables (CAT5)

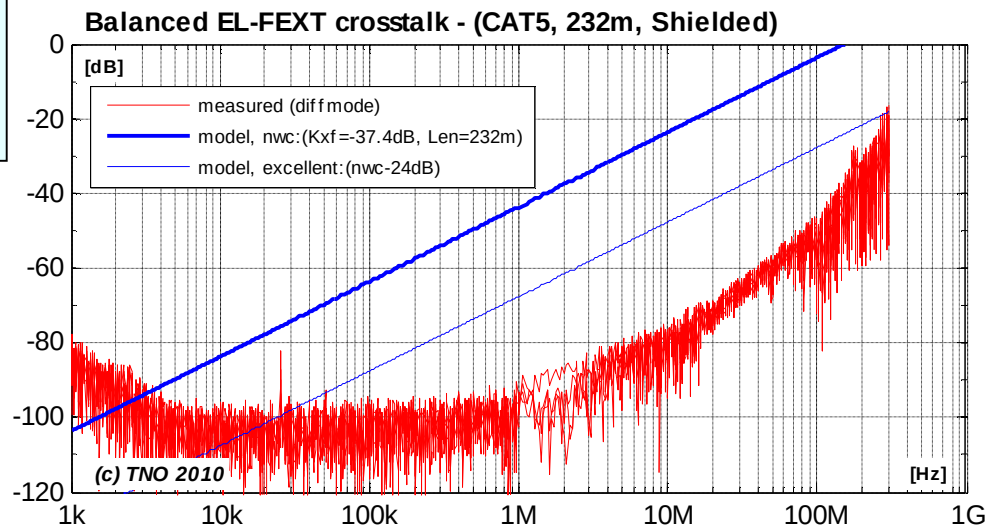
Balanced EL-FEXT Crosstalk:
much better then “excellent”



Theoretical bitrates:
use of VDSL2, 30 MHz spectra:
use of 2 bonded pairs (“quads”)
use of classic simulation models
- 50m **à** >500 Mb/s
- 200m **à** >460 Mb/s

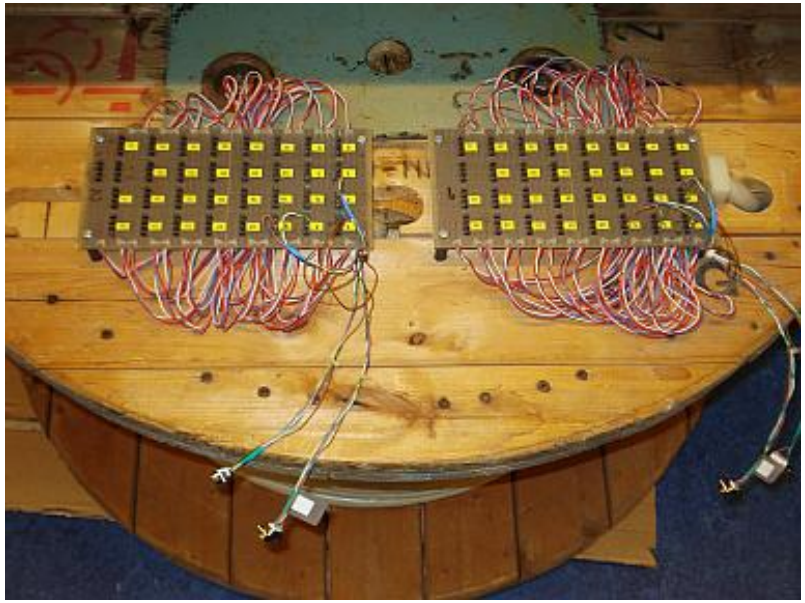
more with dedicated DSL / G.hn



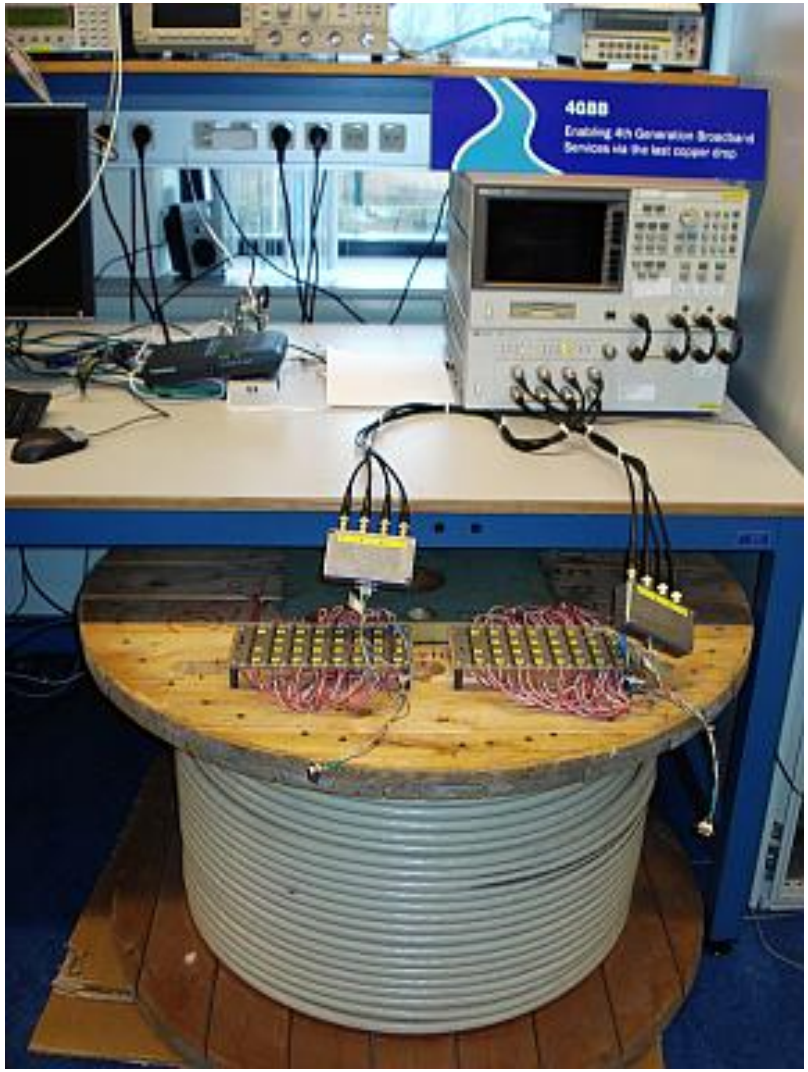


4. Characterizing medium quality cables (telephony)

- 30 twisted-quads (2×2 pair)
- shielded
- telephony wiring for buildings



interconnection with measurement setup

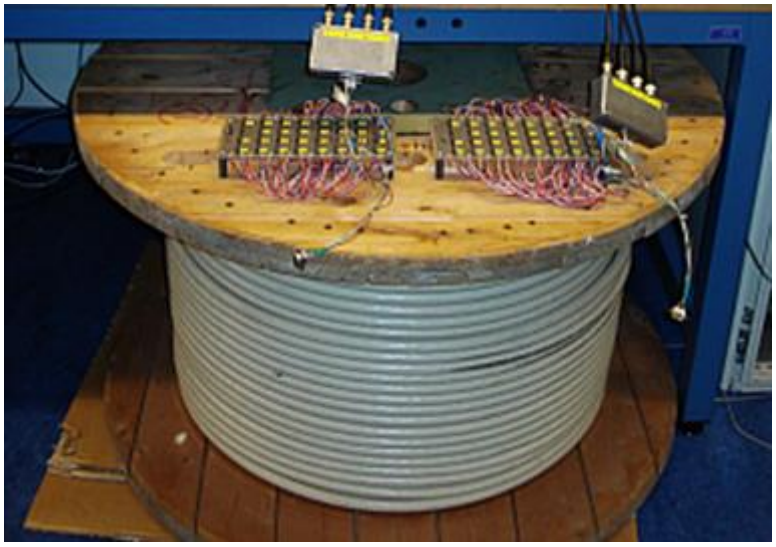


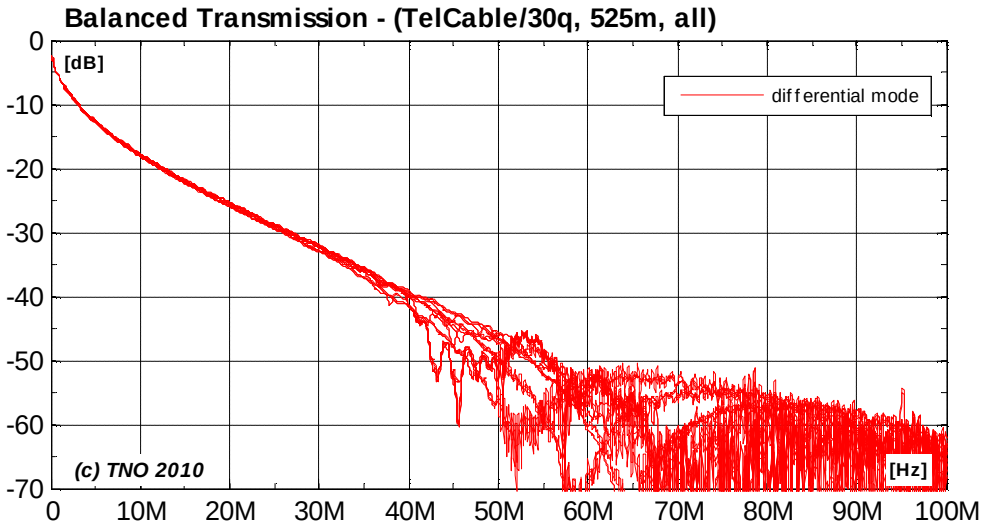
525m on a drum

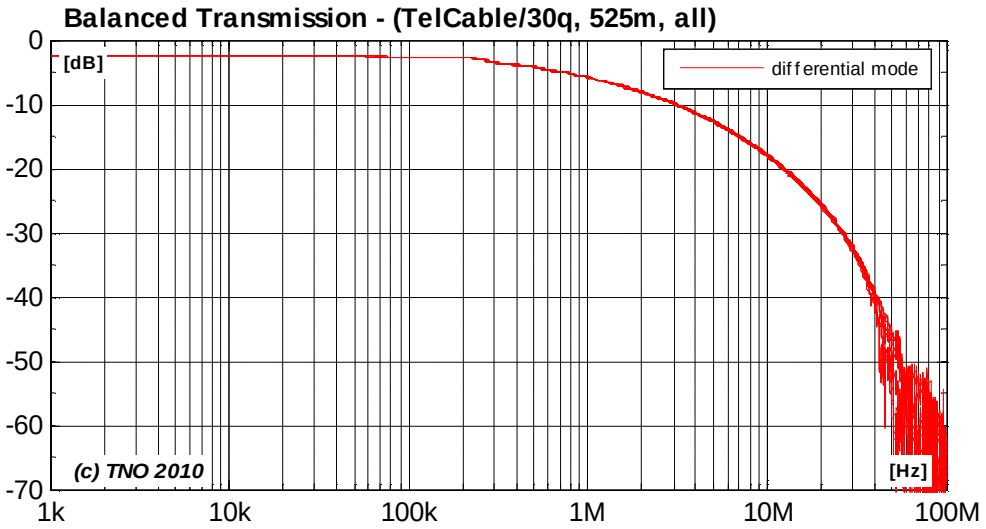
4. Characterizing medium quality cables (telephony)

Balanced Transmission:

3.5 dB / 100m @ 10MHz
13 dB / 100m @ 100MHz

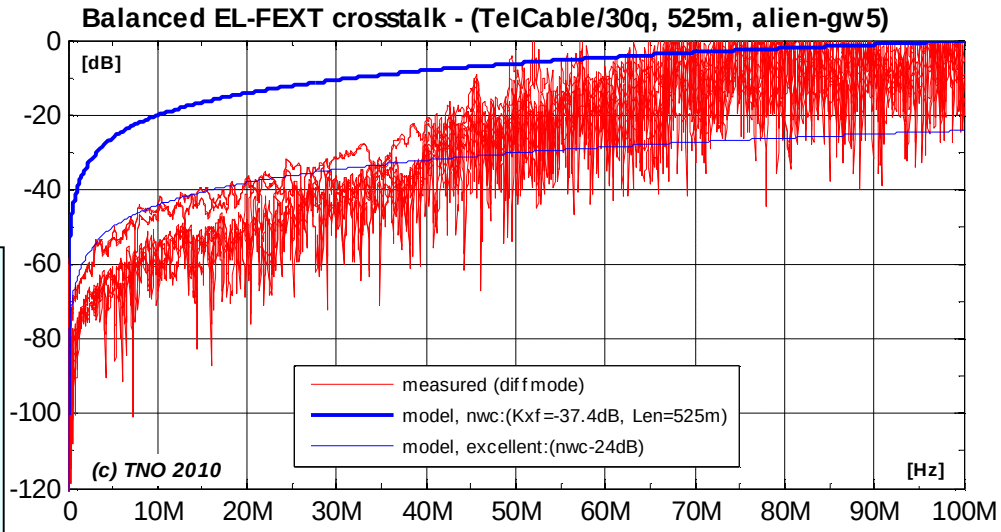






4. Characterizing medium quality cables (telephony)

Balanced EL-FEXT Crosstalk:
"excellent" quality



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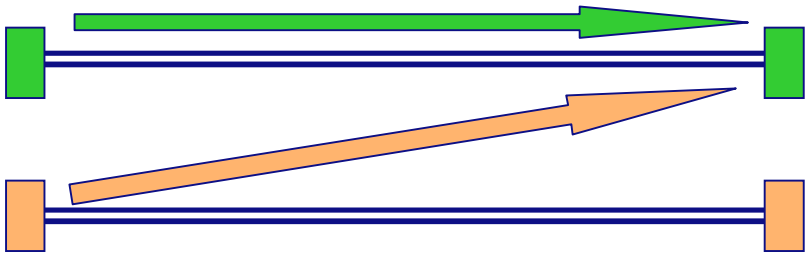
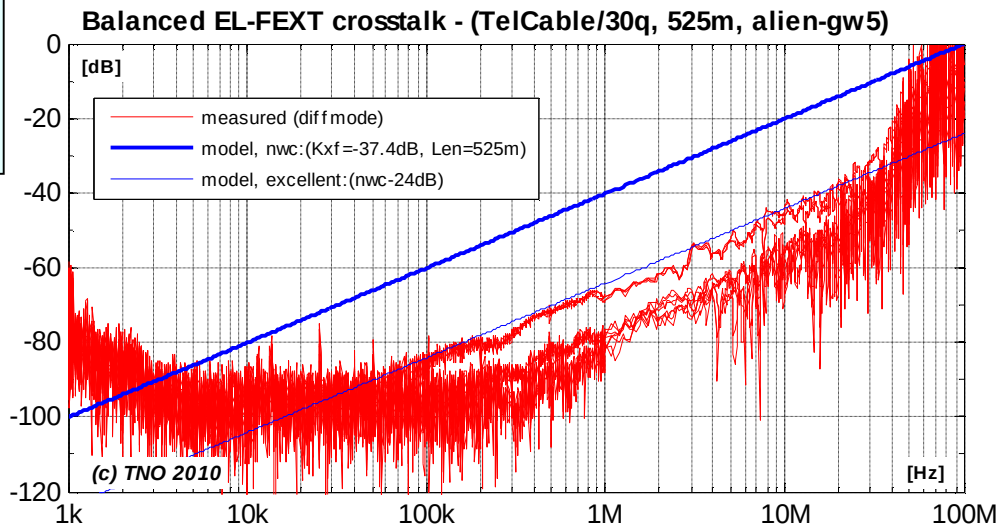
more with dedicated DSL / G.hn





4. Characterizing low quality cables (very cheap)

- fully untwisted
- fully undefined “telephony wiring”
- unshielded
- found in consumer shop “GAMMA”
- 25m

gamma

Lammenschansweg 130
2321 JX LEIDEN
+31 71 5315147

Klantenkaart: 2811008608818

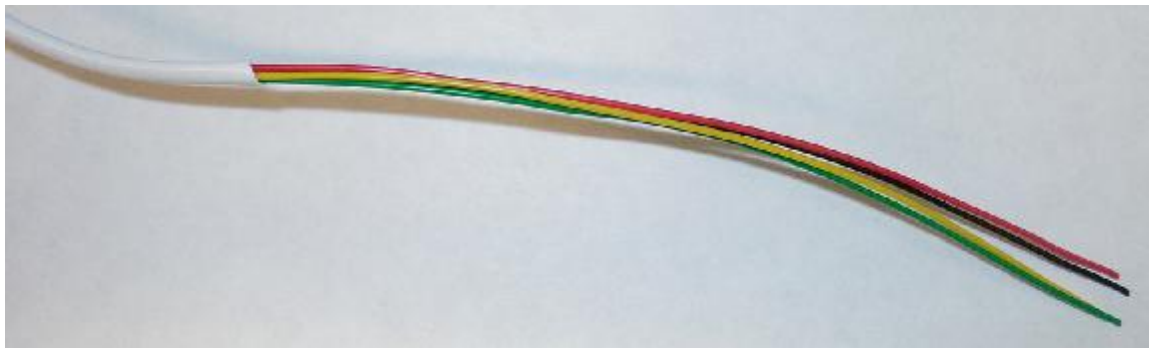
AANT	OMSCHRIJVING		PRIJS	BEDRAG	BTW
1	HOEK ALUMINIUM	25X25X2MM 1M	4,79	4,79	1
4	TELEFOONDRAAD RUND	4X0,5MM 25M	5,99	23,96	1
1	GAMMA BIG SHOPPER		1,00	1,00	1
1	BERKEN MULTIPLEX	15MM 122X61CM	18,49	18,49	1

7 Totaal 48,24
Pin 48,24

BETAALAUTOMAAT
Datum 27/01/10 Rijd 16:09:23
Kassanr VM8106 Referentie 01091441

Totaal 48.24 EUR

Tlv 0315638842
BANK Bet kenmerk 027NUT
Acquirer identifier: 67300110
U HEEFT BETAALD
TOT ZIENS

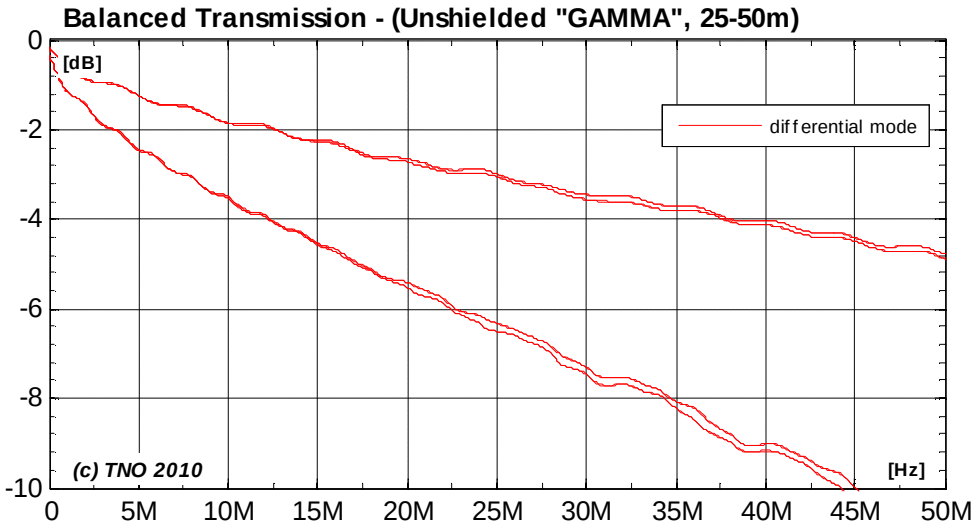


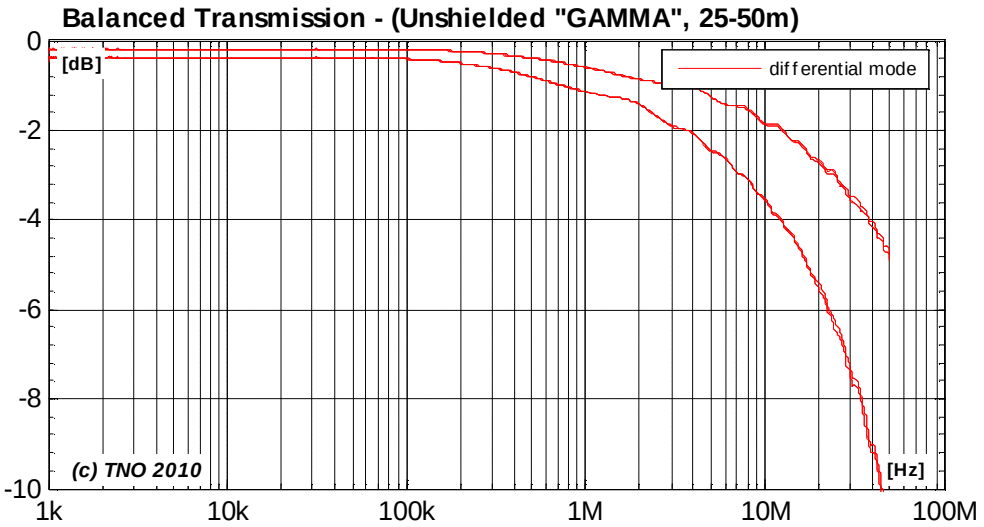
25m or 25+25m spread-out on the floor

4. Characterizing low quality cables (telephony)

Balanced Transmission:

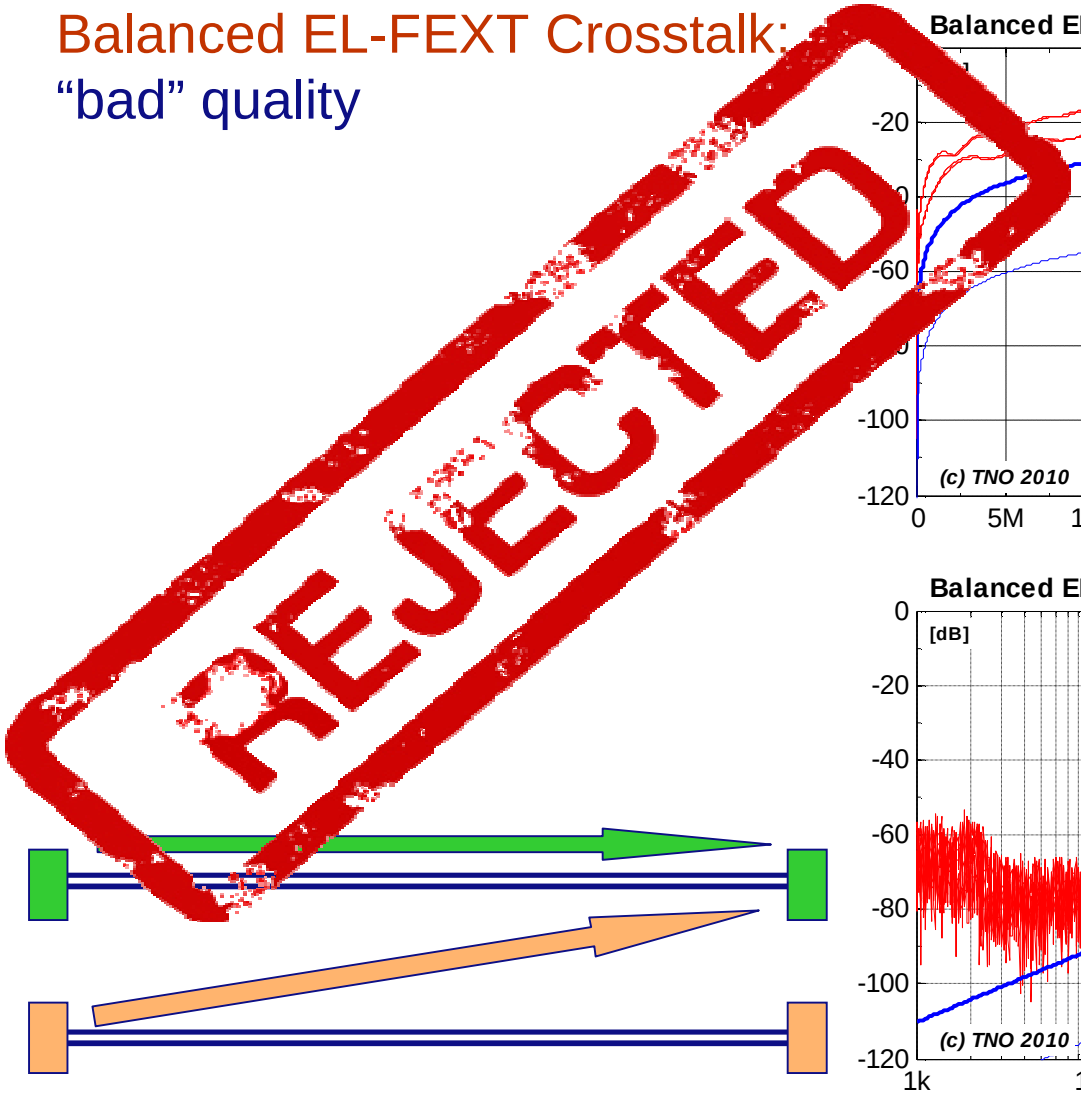
7 dB / 100m @ 10MHz
40 dB / 100m @ 100MHz

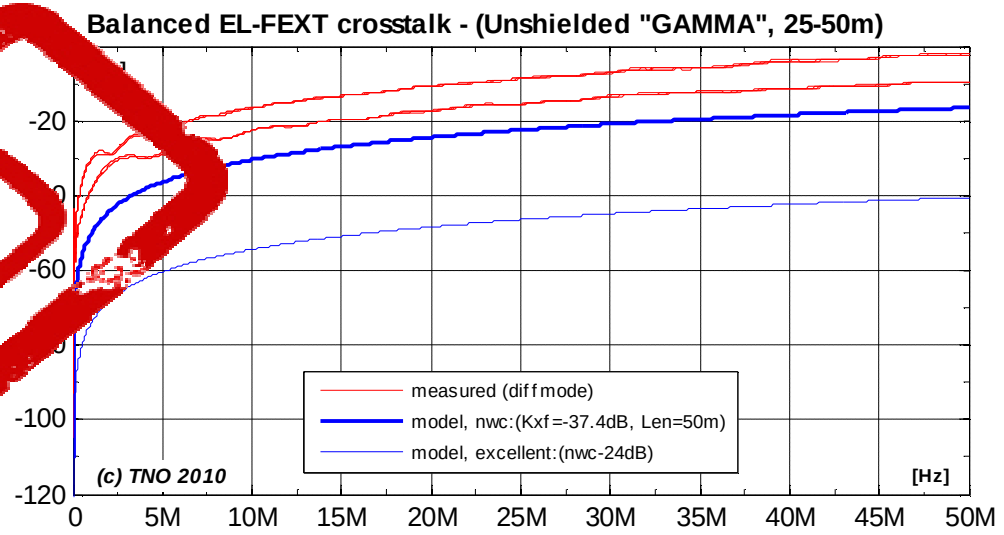


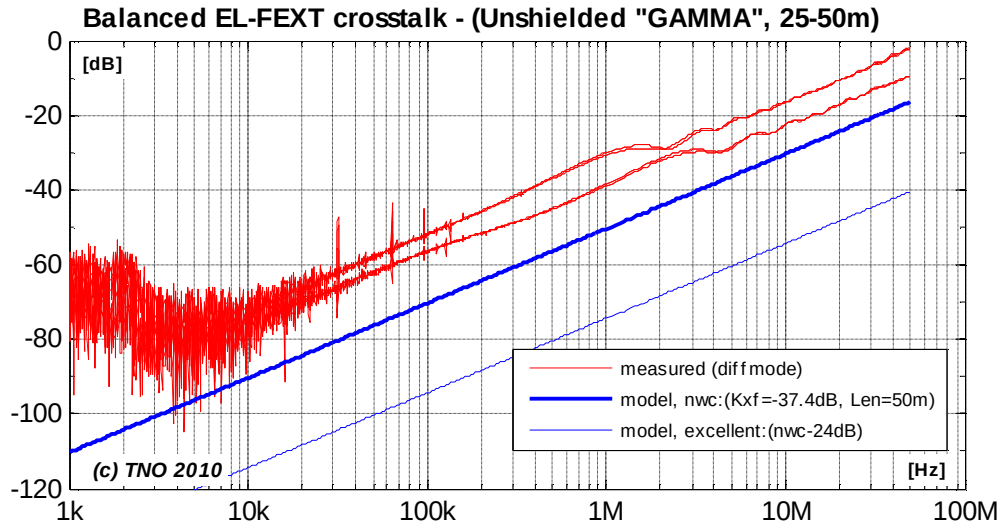


4. Characterizing low quality cables (telephony)

Balanced EL-FEXT Crosstalk: “bad” quality



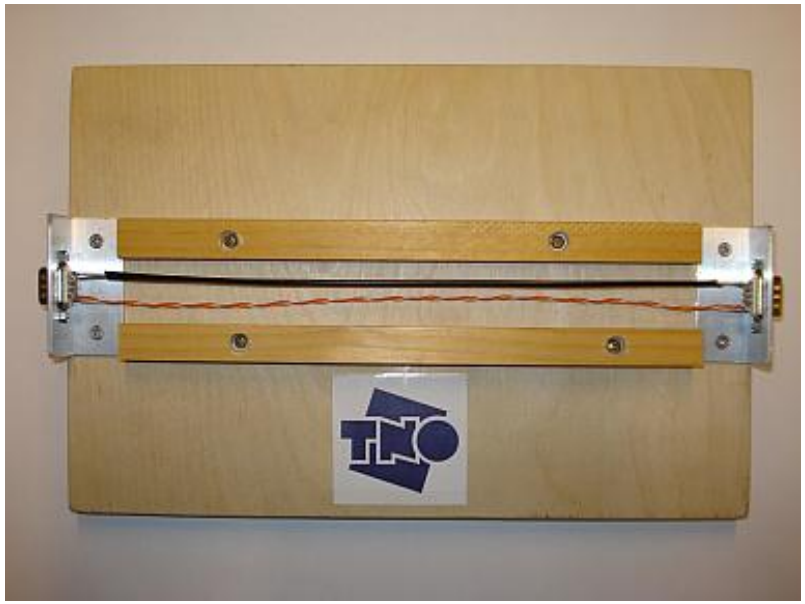


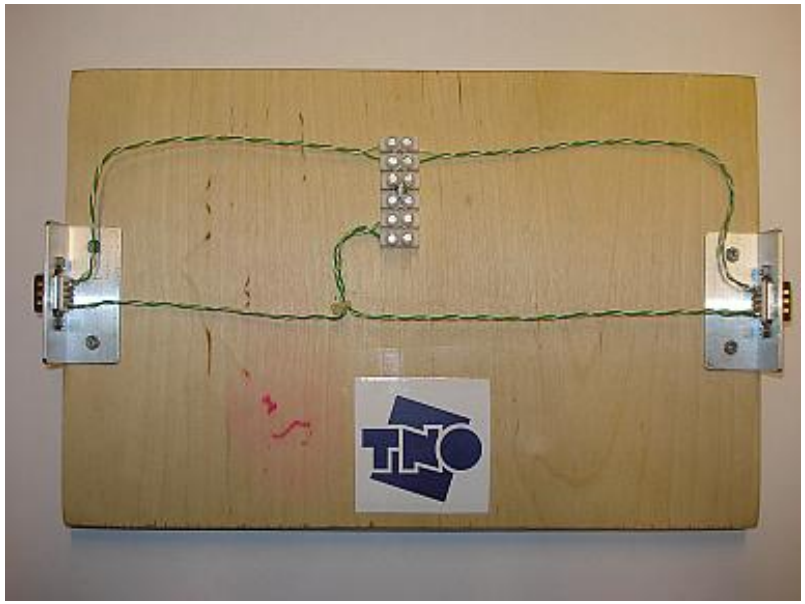


4. Characterizing splices and other obstacles

Replica's from common practice

- straight untwisted pair
- straight twisted pair
- interconnection ("home brew")
- simulation of a cable splice





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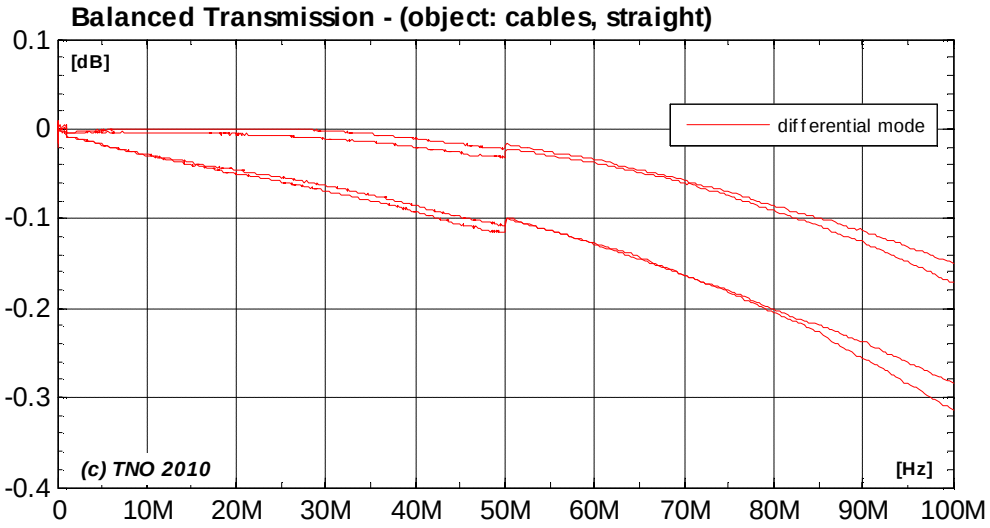
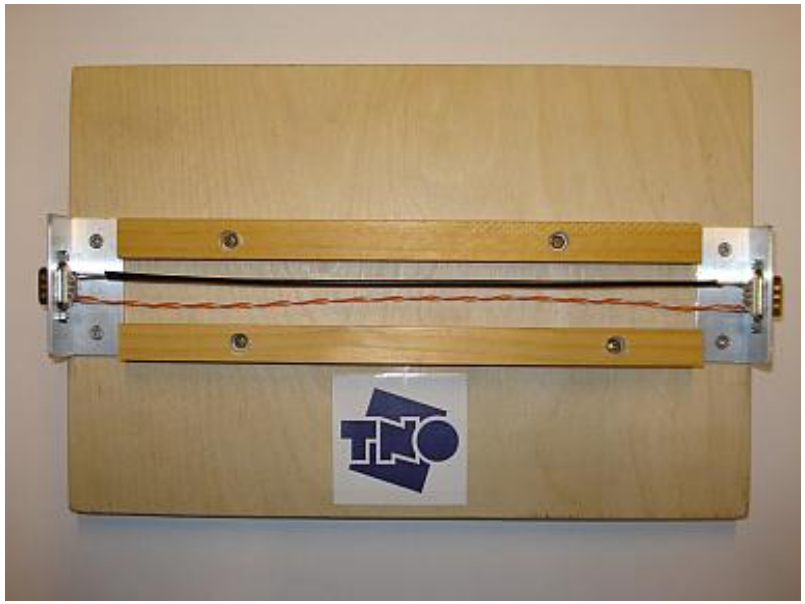
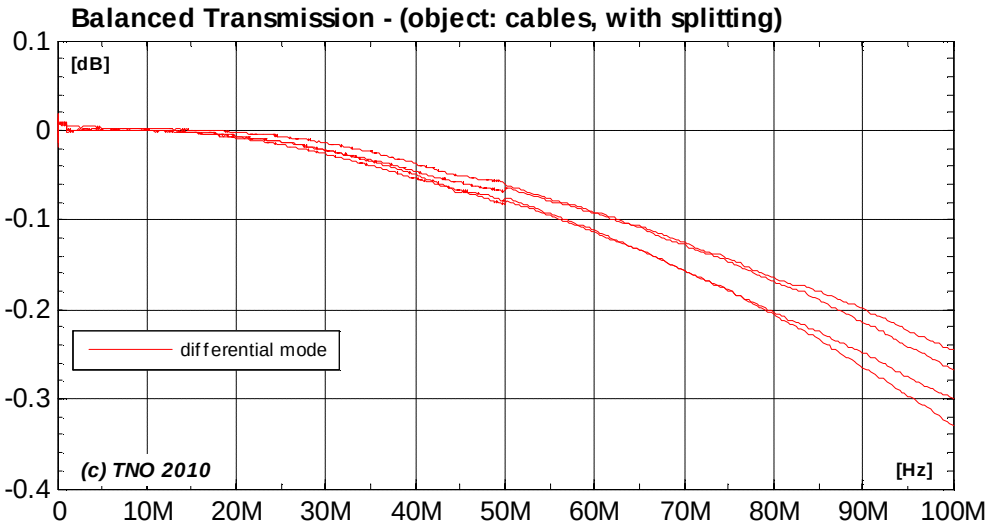
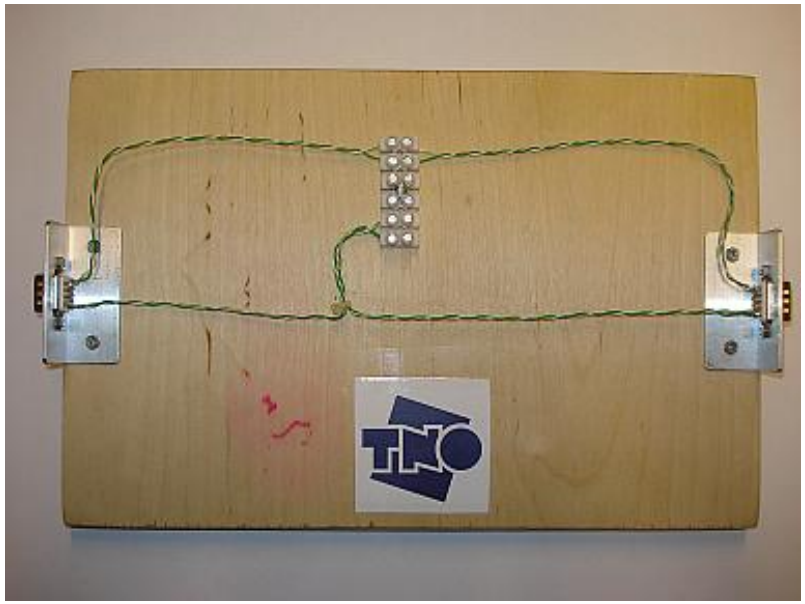
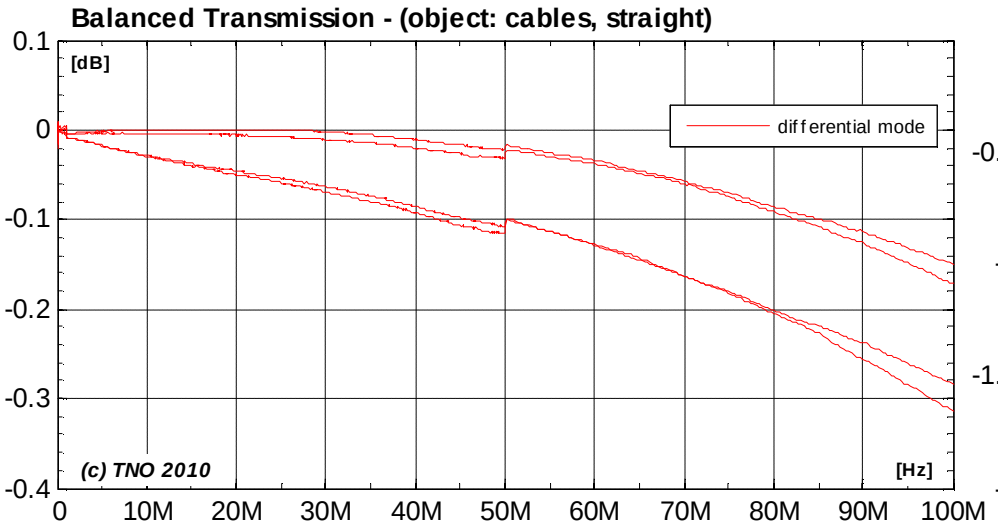


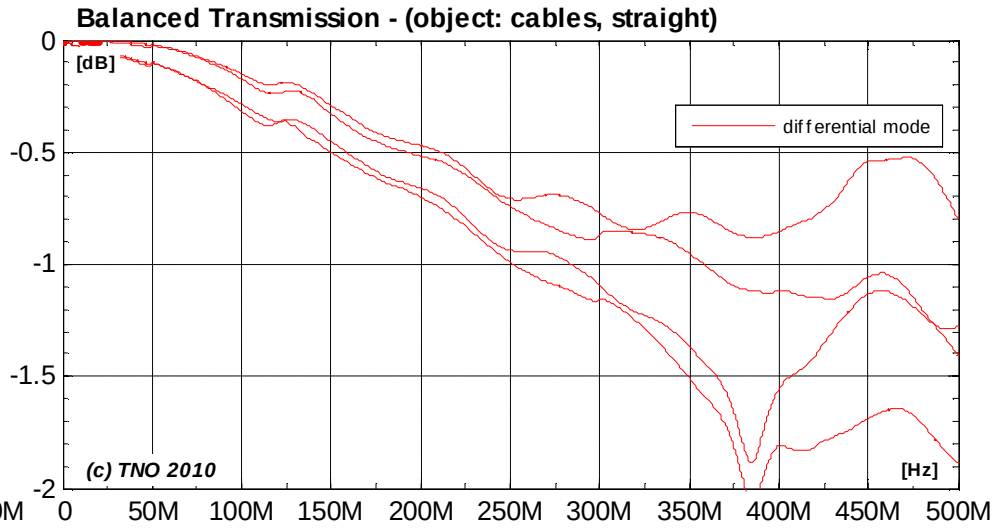


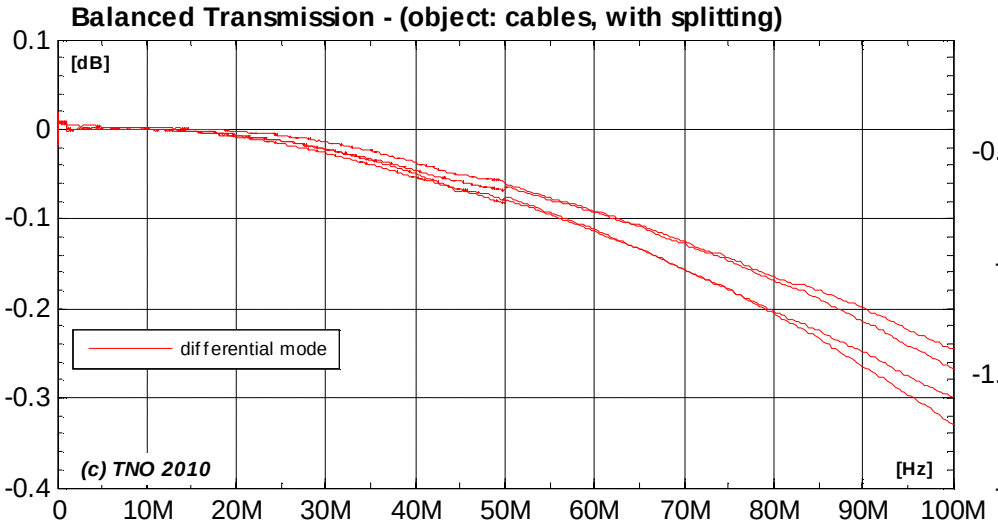


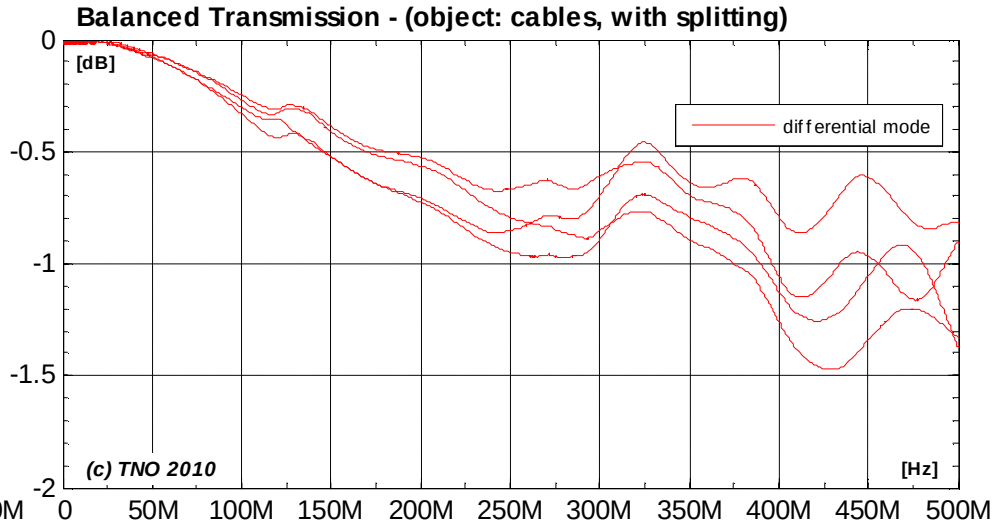


4. Characterizing splices and other obstacles









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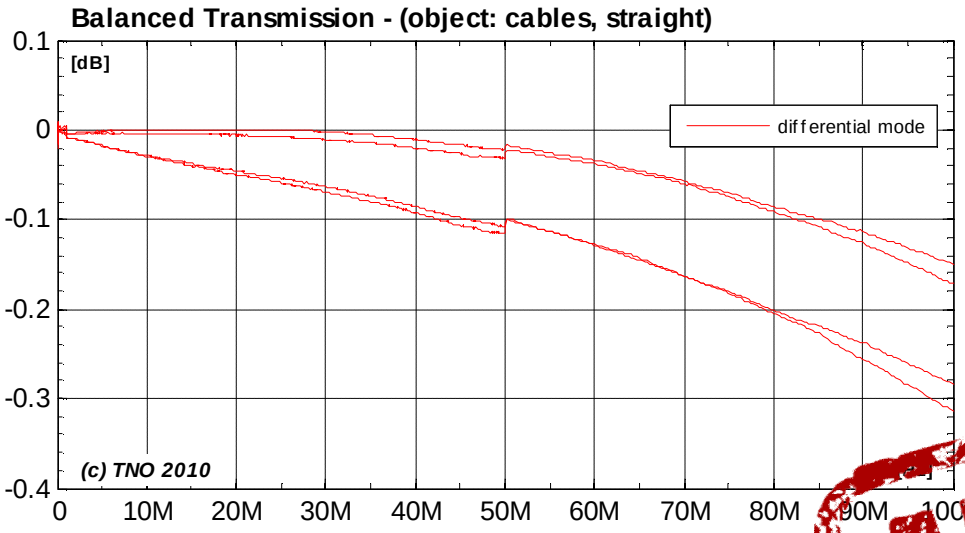

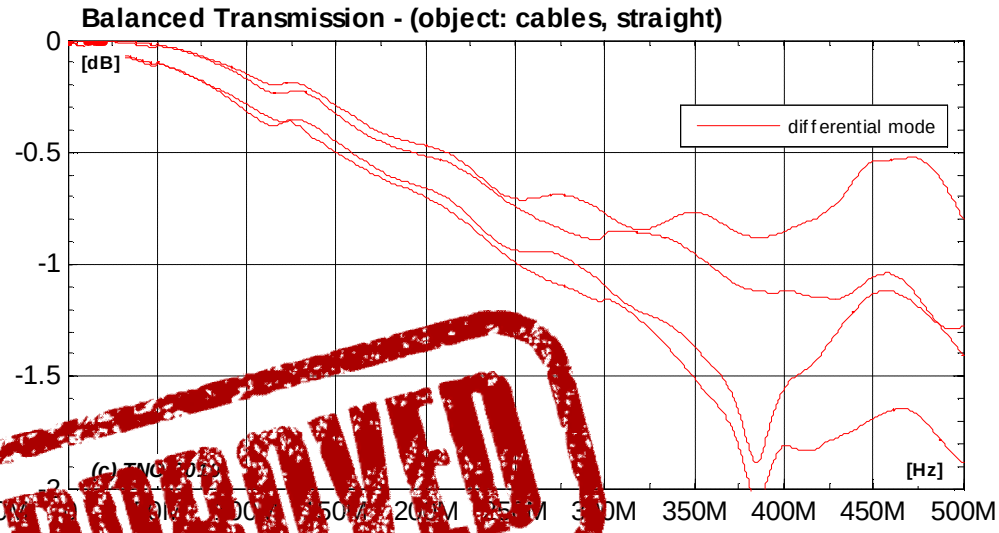

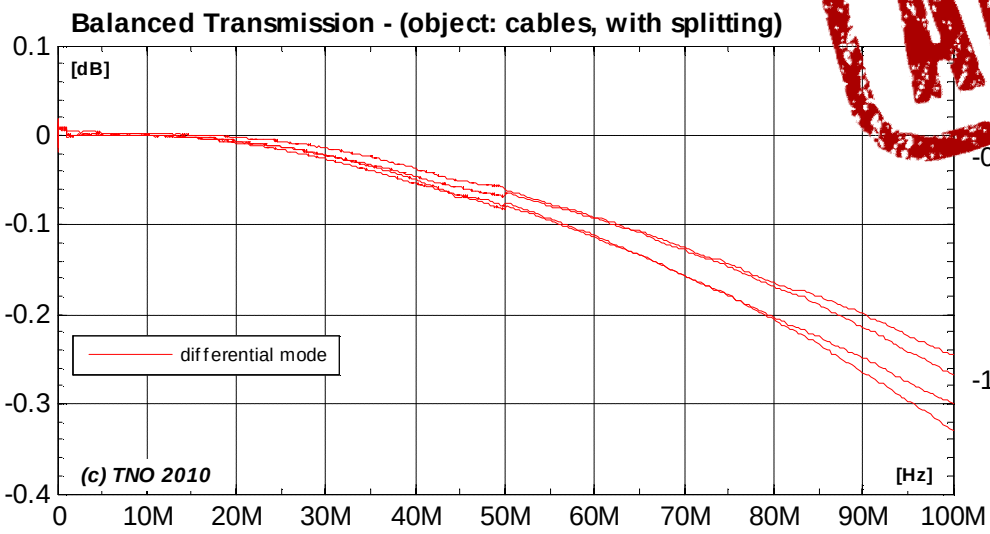

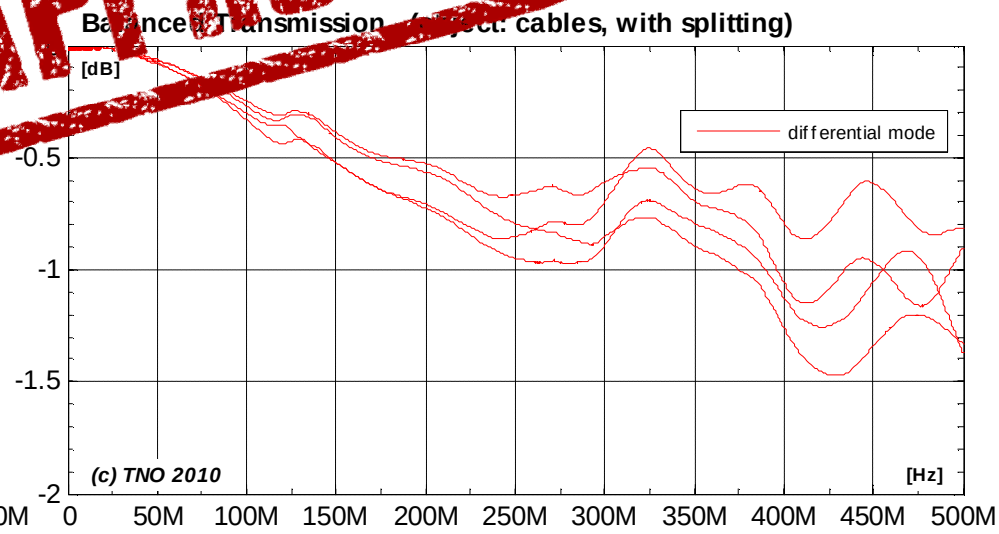

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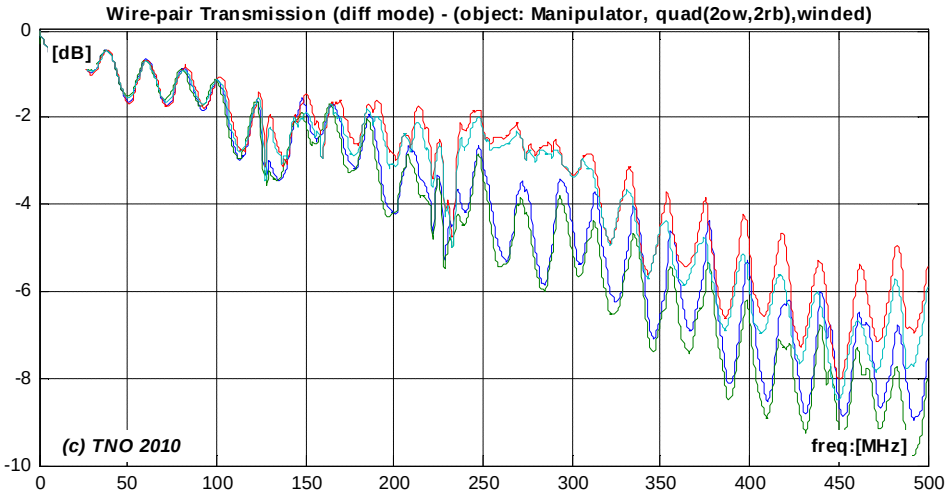

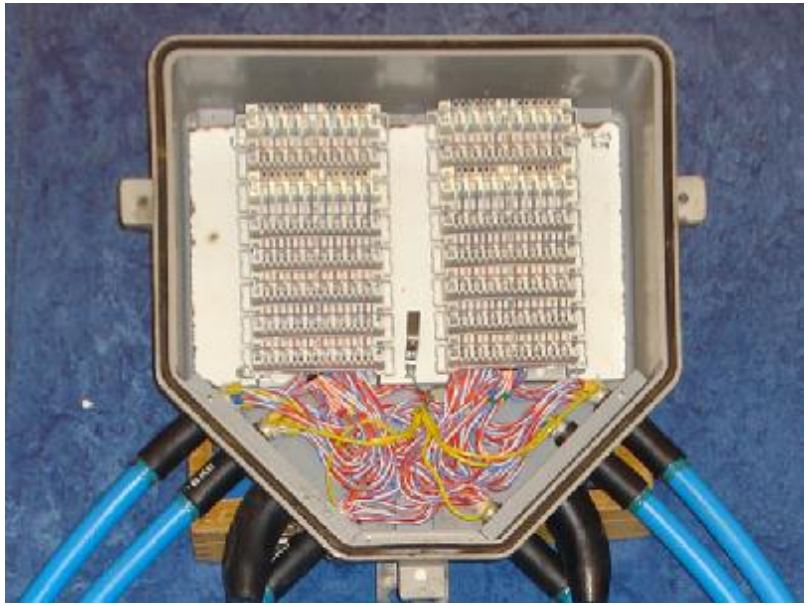

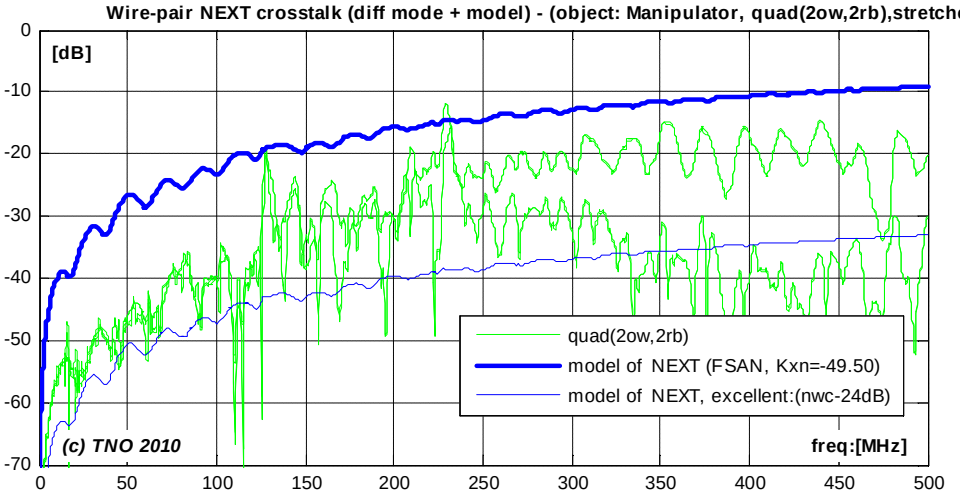

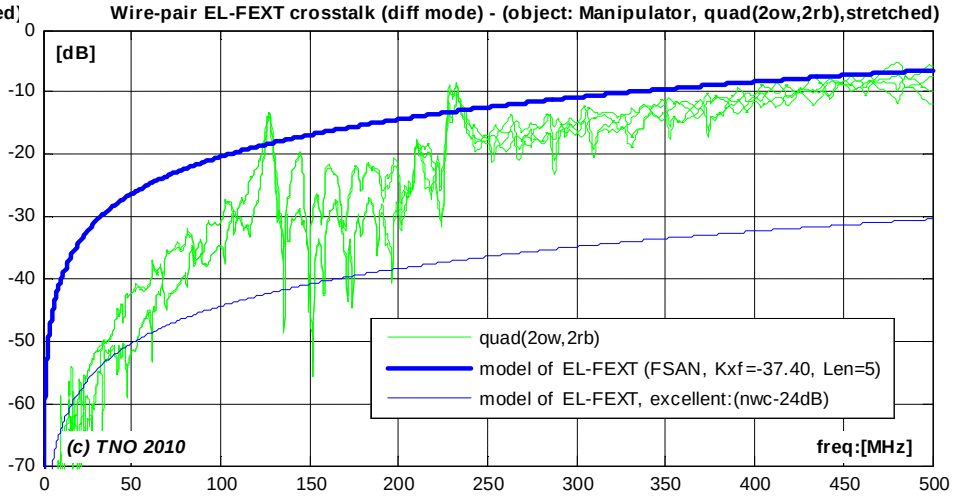

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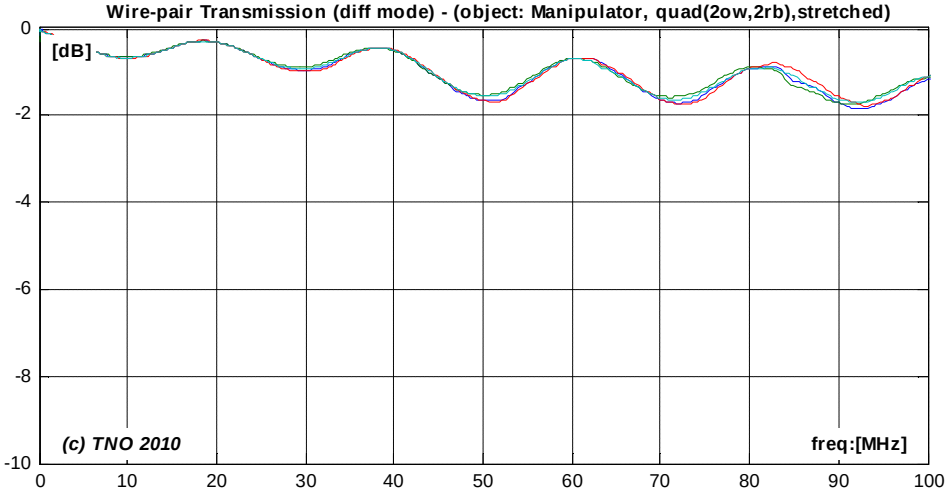

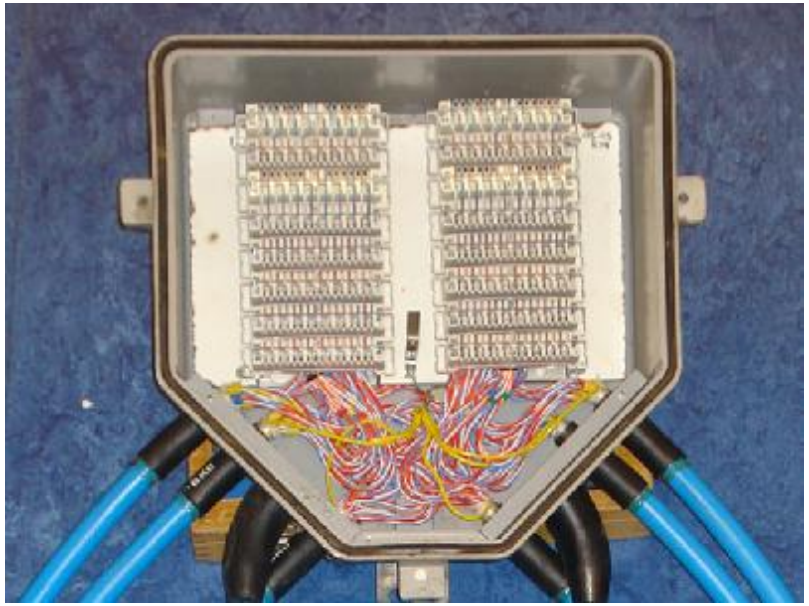

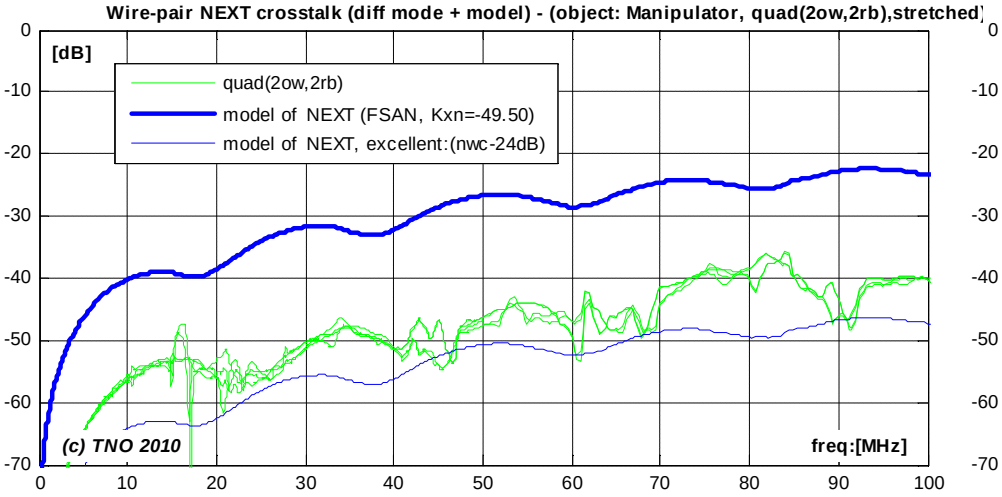

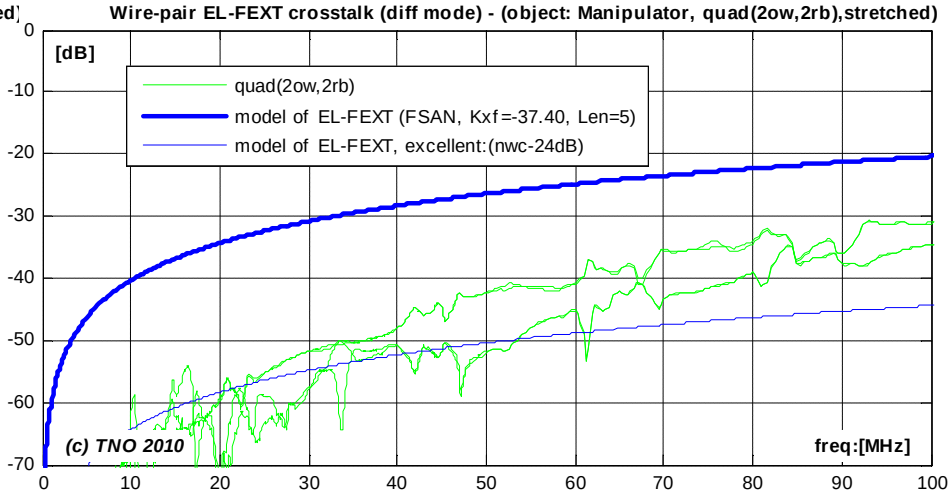

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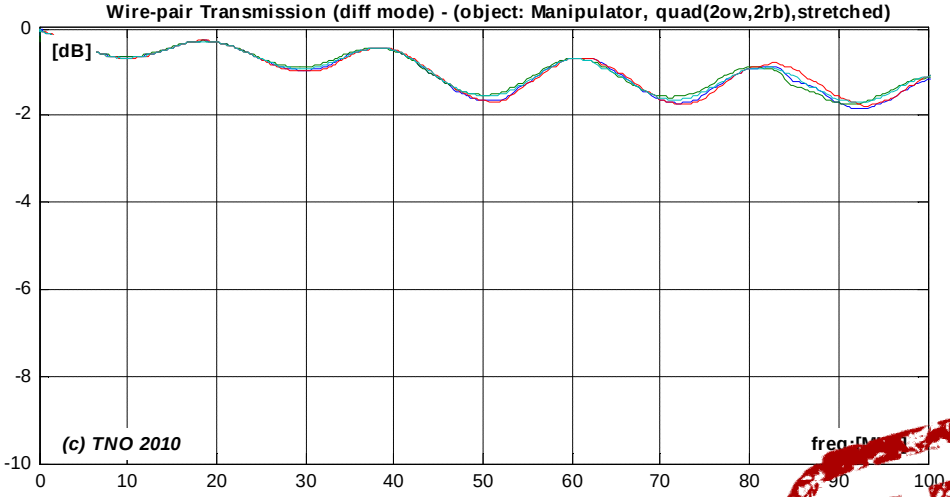
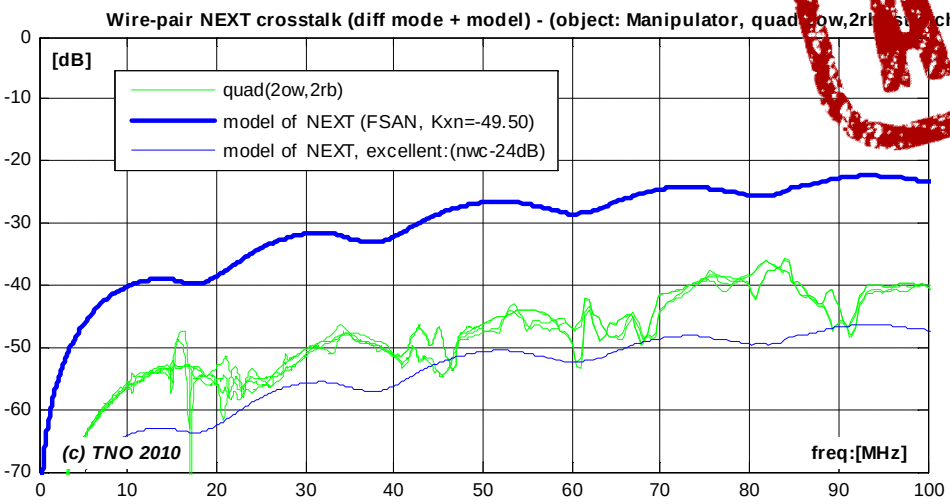
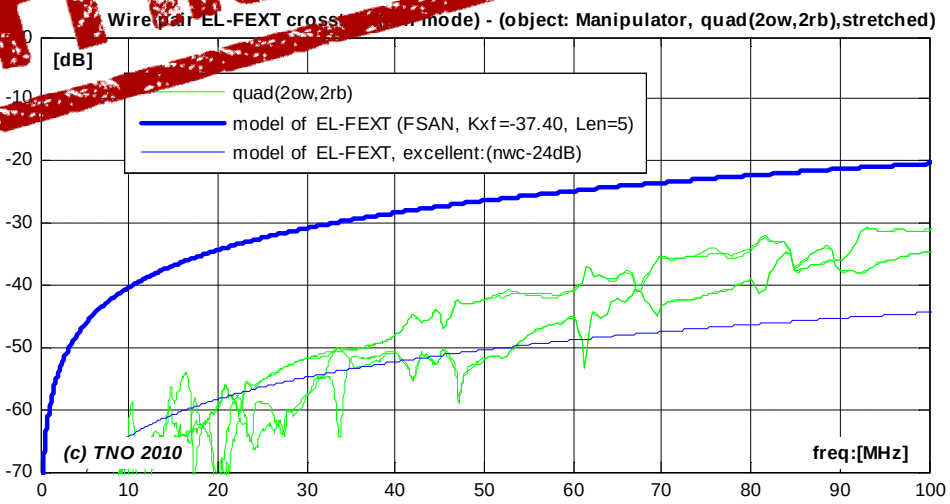


APPROVED





5. Further actions, for the next two years

- Techno-economic studies
  - when and where is it attractive?
  - quantifying cost-savings
- Further characterization of access network
  - operational cables/installation
  - noise, ingress, egress, etc
  - modeling, prediction of bitrates
- Development of dedicated DSL technologies
  - by other partners in 4GBB/Celtic consortium
- Bring the industry in motion
  - gain more interest from industry & operators
  - initiation of standards **Via BBF -> ITU**
  - publicity: DSL seminar (Delft), white papers via BBF, …

6. Conclusions

enabling 4GBB via hybrid FttH:

- Hybrid FttH is an attractive extension to full FttH
  - might be more effective in cost for several cases (20%?, 30%?, …)
  - might be faster to install for several cases
  - might lower the threshold for offering 4GBB speeds
- Hybrid FttH is technically feasible
  - the first cable measurements made this plausible
  - its essentially a mix of Gb/s Ethernet and DSL solutions
- Hybrid FttH is applicable today for 3GBB+
  - 30MHz variants of VDSL2 already standardized
  - G.hn is also a possibility
  - many customer premises connected via quads for 2 bonded pairs
  - targeted for existing wiring in apartment buildings

lets standardize the missing DSL technology for 4GBB!

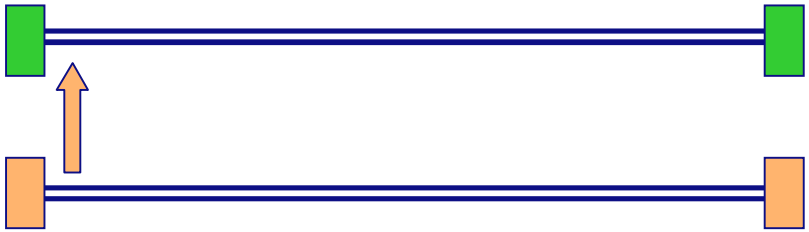
Back-up slides

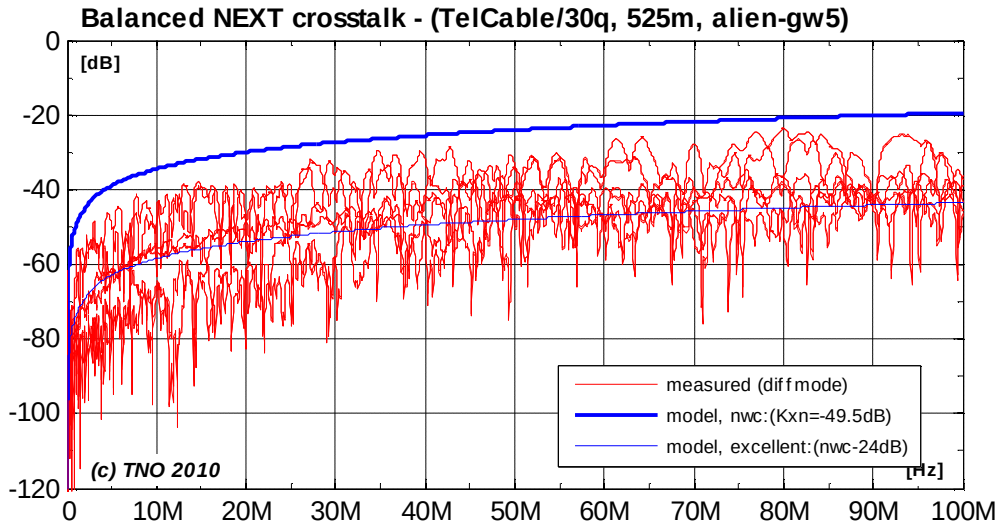
TNO | Kennis voor zaken

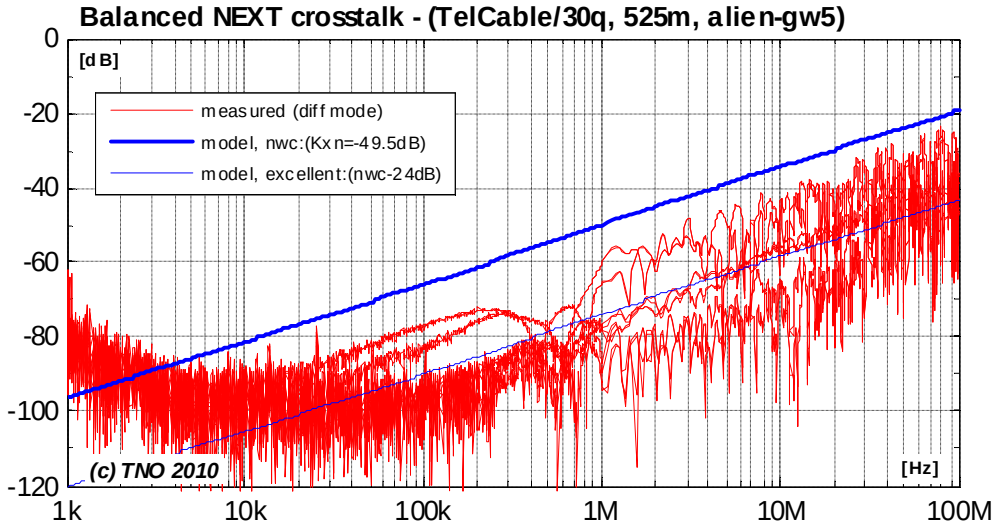
4. Characterizing medium quality cables (telephony)

Balanced NEXT Crosstalk:

typical telephony quality



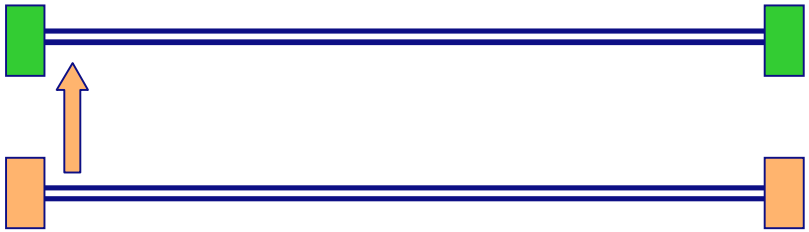


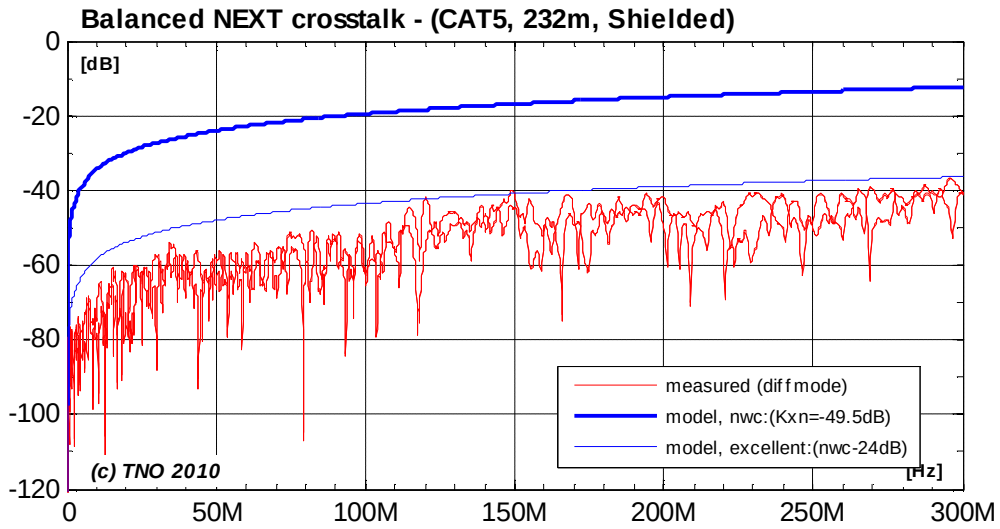


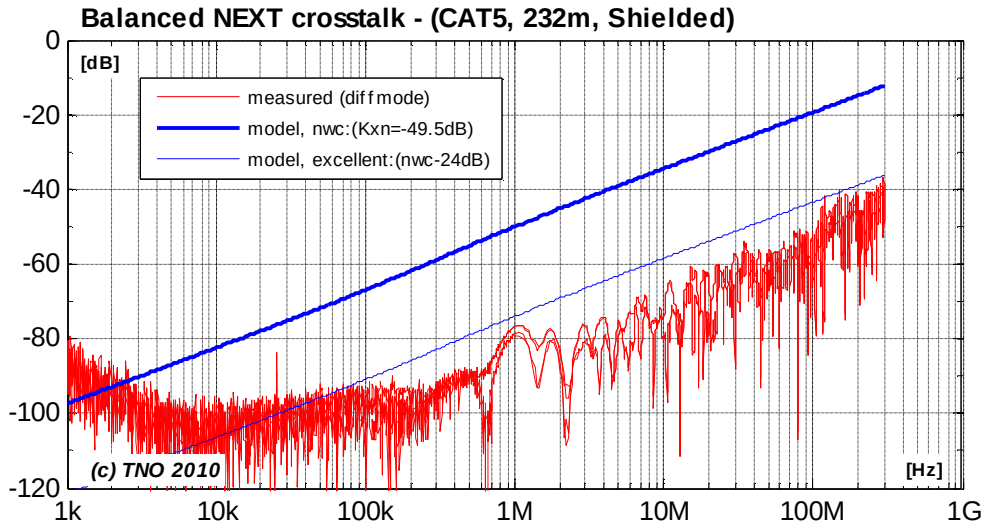
4. Characterizing high quality cables (CAT5)

Balanced NEXT Crosstalk:

better then “excellent”







4. Characterizing low quality cables (telephony)

Balanced NEXT Crosstalk:

“bad” quality