IEEE 802.3 Gigabit Ethernet Over Plastic Optical Fiber Study Group

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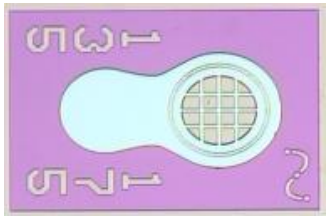
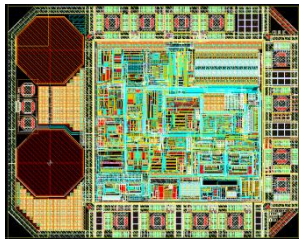
Firecomms' Core Capabilities

Photonics (Light Sources) III-V Semiconductor	Driver & Receiver IC's Si CMOS Semiconductor	Device Assembly Packaging & Connectors
High Speed Resonant Cavity LED / VCSEL	Custom designed for fiber applications	Optical modelling and lens integration
Visible Light Range 455 ~ 680nm Near IR 850nm	Specialised Mixed Silicon IC team	Low cost, reliable transparent mould and high temp leadframes
Resonant Cavity technology for low current consumption	Novel driver IC architectures	Production assembly and test techniques
Optical beam shaping for efficient coupling and long term reliability	Robust receiver IC topologies	Innovative connector design
Cost effective 4" wafer processing	Cost effective 35 nm 8" process	High Reliability assembly operations



RCLED die



Dual PD die CMOS Rx chip

Transfer molded lead formed FOT

POF_PLUS

FP7 STEP Project: May 2008 to May 2011

1 GbE POF System Requirements

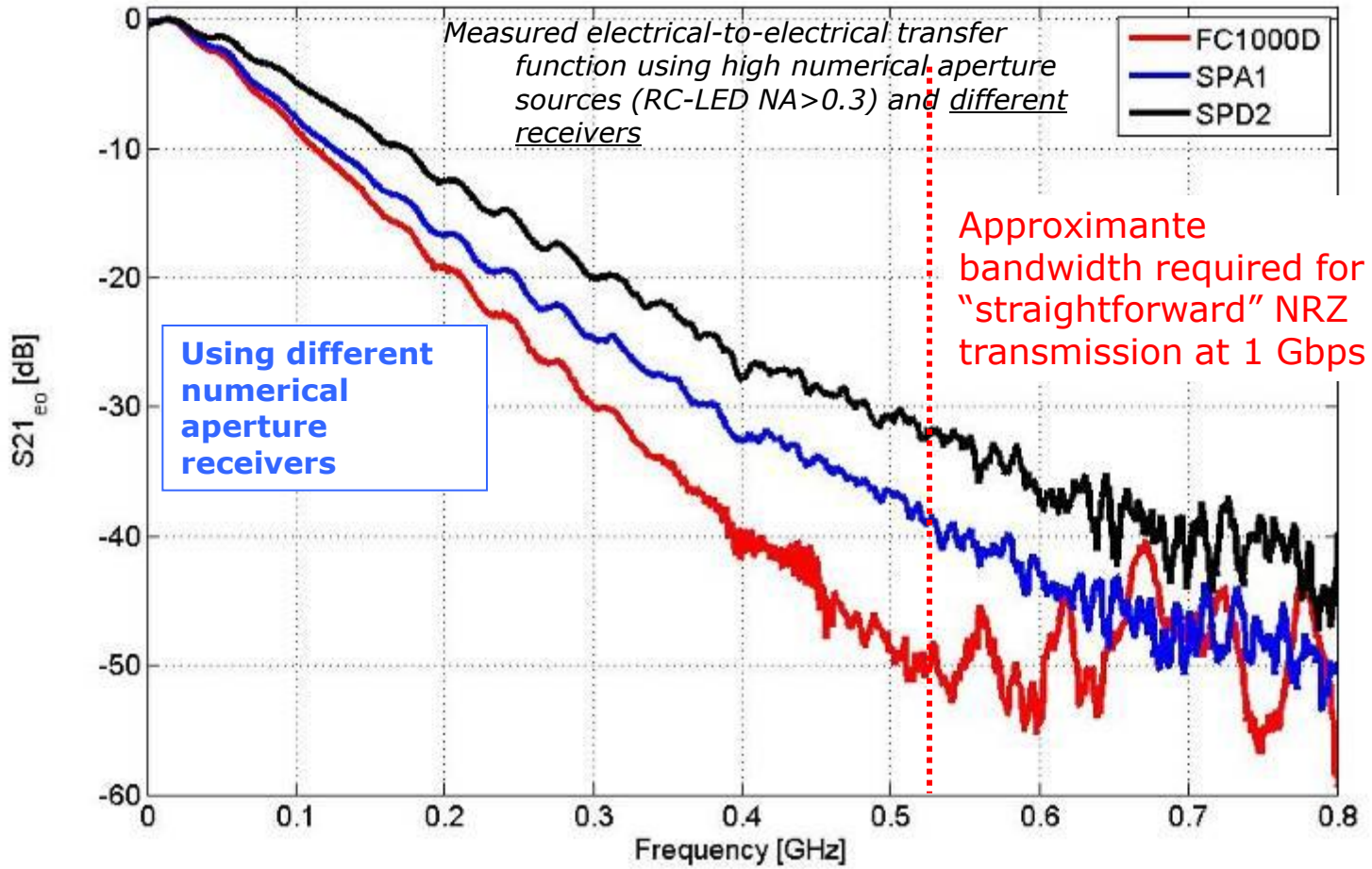
- Low Cost- commercially viable solution
- Target Link length 50 m
- Target data rate of 1 Gbps < 1 E-9 BER
- Reliable system margin (4-5 dB) over life-time and operating temperature
- Low Latency
- Compatible with GbE Standards
- Compatible with a connector-less interface
- Backward Compatible with Fast Ethernet POF Solutions
- Provide adaptive data rates
- Low power consumption
- Meets class 1 eye safety standards

Technical Specification: ETSI

ETSI TS 105 175-1 V2.0.0 (2011-10)

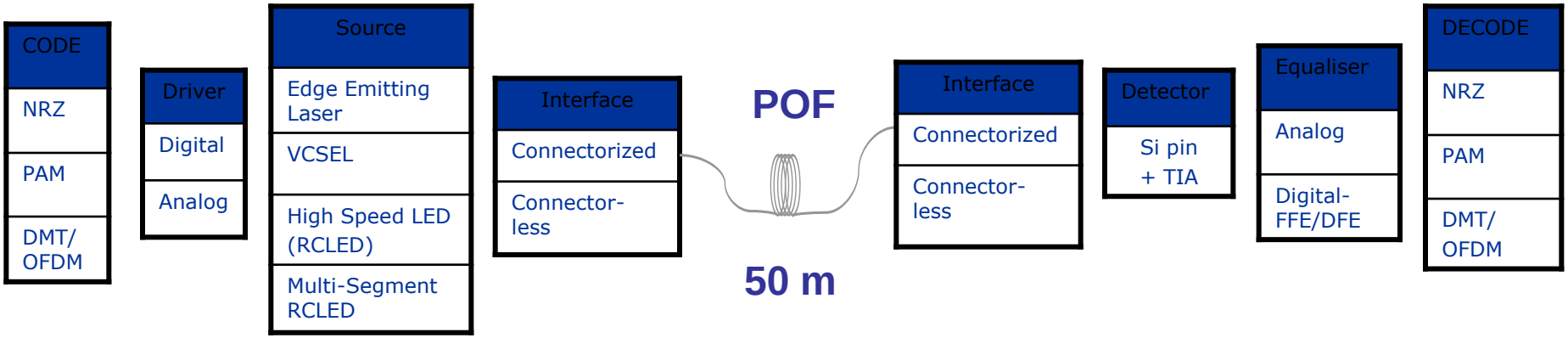
Access, Terminals, Transmission and Multiplexing (ATTM);
Plastic Optical Fibre System Specifications

Bandwidth over 50m POF: Need for DSP



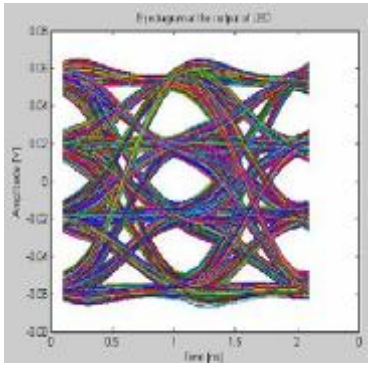
On top of limited bandwidth, there is also a significant attenuation in POF (of the order of 0.2 dB/m at red wavelengths)

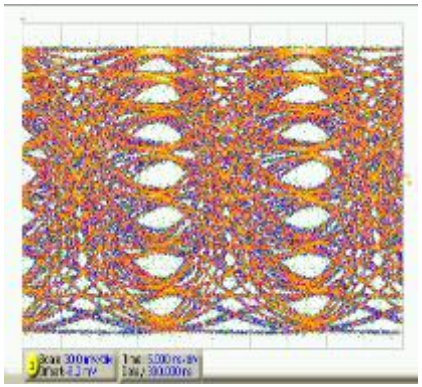
Technology Options for 1 Gbps over SI-POF



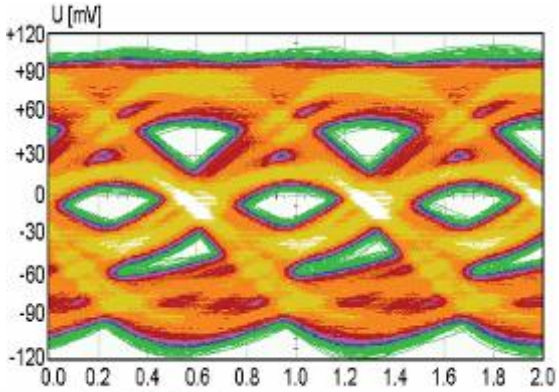
POF PLUS R&D

- Multilevel modulation
  - 4-PAM or 8-PAM
  - Pre-emphasis at the TX

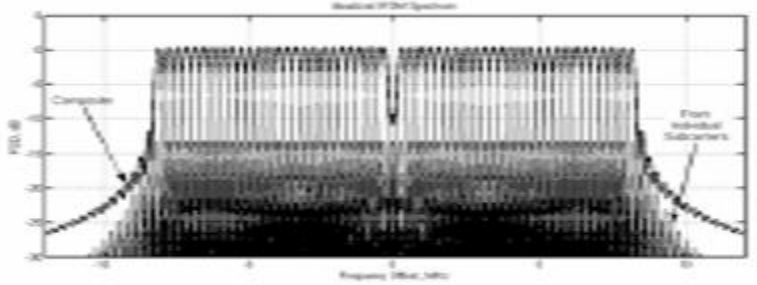




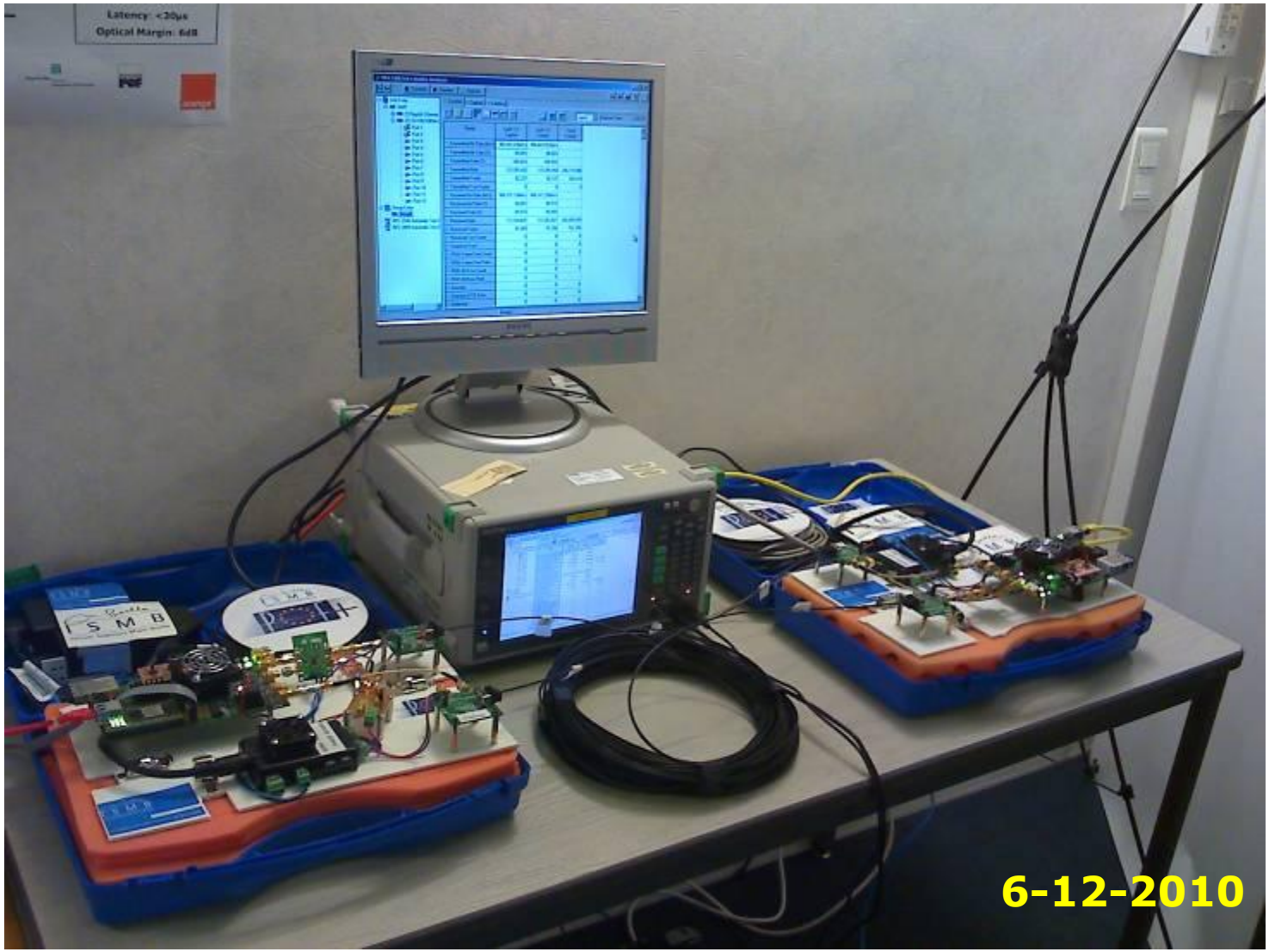
- NRZ & Adaptive Rx equalization
  - Feed-forward MMSE FIR filters
  - Decision-feedback filters
  - Simple analog equalizers



- OFDM/DMT modulations
  - adaptive



Measurement Campaign – France Telecom

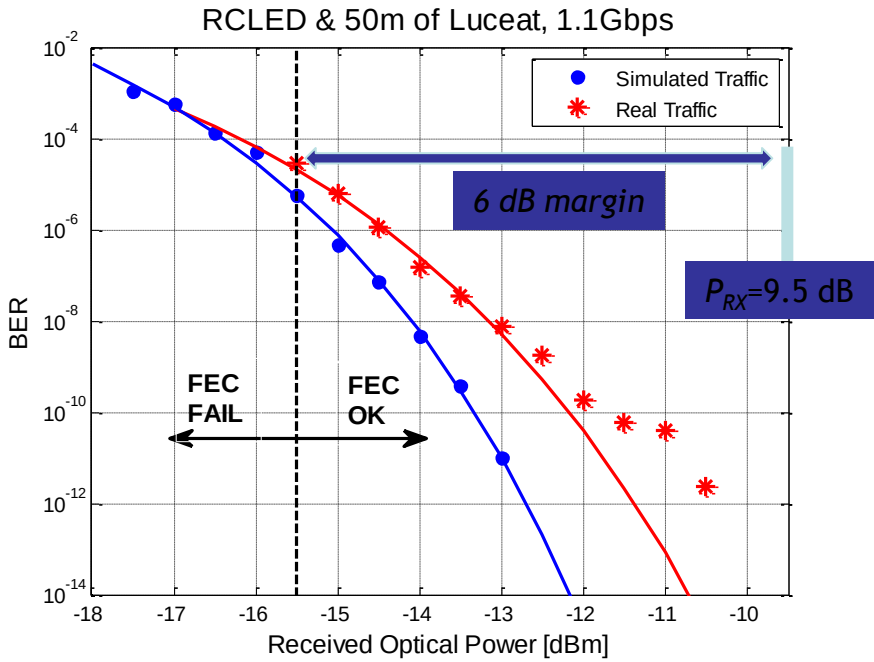


EU project POF-PLUS

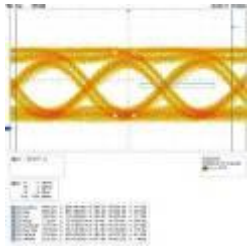
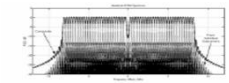
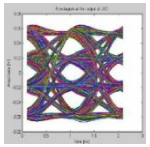
Solution Developed by ISMB Group:

- RCLED based setup
- Optimized RC-LED driver
- Pure NRZ at transmitter (i.e., no DSP at TX)
- Adaptive DFE equalization at receiver
- Simple Reed-Solomon FEC

- Achieved 1 Gbps (net data rate, compliant with Gigabit Ethernet) over 50 meters POF with 6 dB system margin



Perspective: Advantages/Disadvantages

TECHNOLOGY	ADVANTAGES	DISADVANTAGES
NRZ  RCLED 70ºC	1. Low cost Gbps solution for short link lengths (5 -10 m) 2. Can be implemented with RCLEDs operating at 1 Gbps- ideal for life-time and eye-safety requirements 3. Enables stand-alone digital-in/digital-out transceivers that interface directly with the GbE PHY 4. Could down-rate to Fast Ethernet 5. Lowest Power Consumption Solution 6. Short time to market	1. Can not achieve a max distance of 50 m 2. To achieve longest link length more complex DFE/FFE equaliser technology required – unlikely to provide sufficient system margin 3. High power red edge emitting lasers probably lack sufficient reliability as an alternative to LEDs
DMT/OFDM 	1. Efficient use of channel bandwidth 2. Adaptive data rates 3. Enables the use of low speed Tx and Rx analog components 4. Possible to re-use current chip sets for DSL, Home-Plug	1. Available OFDM chip sets not optimised for POF 2. Complex DSP ICs required 3. Requires extensive standardisation for interoperability 4. Power hungry 5. Highest cost be-spoke solution 6. Long time to market
M-PAM 	1. Theoretically and Experimentally shown to be the optimum solution for long distances 2. Significantly simpler implementation than OFDM or similar DSP based techniques 3. Adaptive data rates-compatible with NRZ 4. Enables Lower speed Tx and Rx components	1. Requires extensive standardisation

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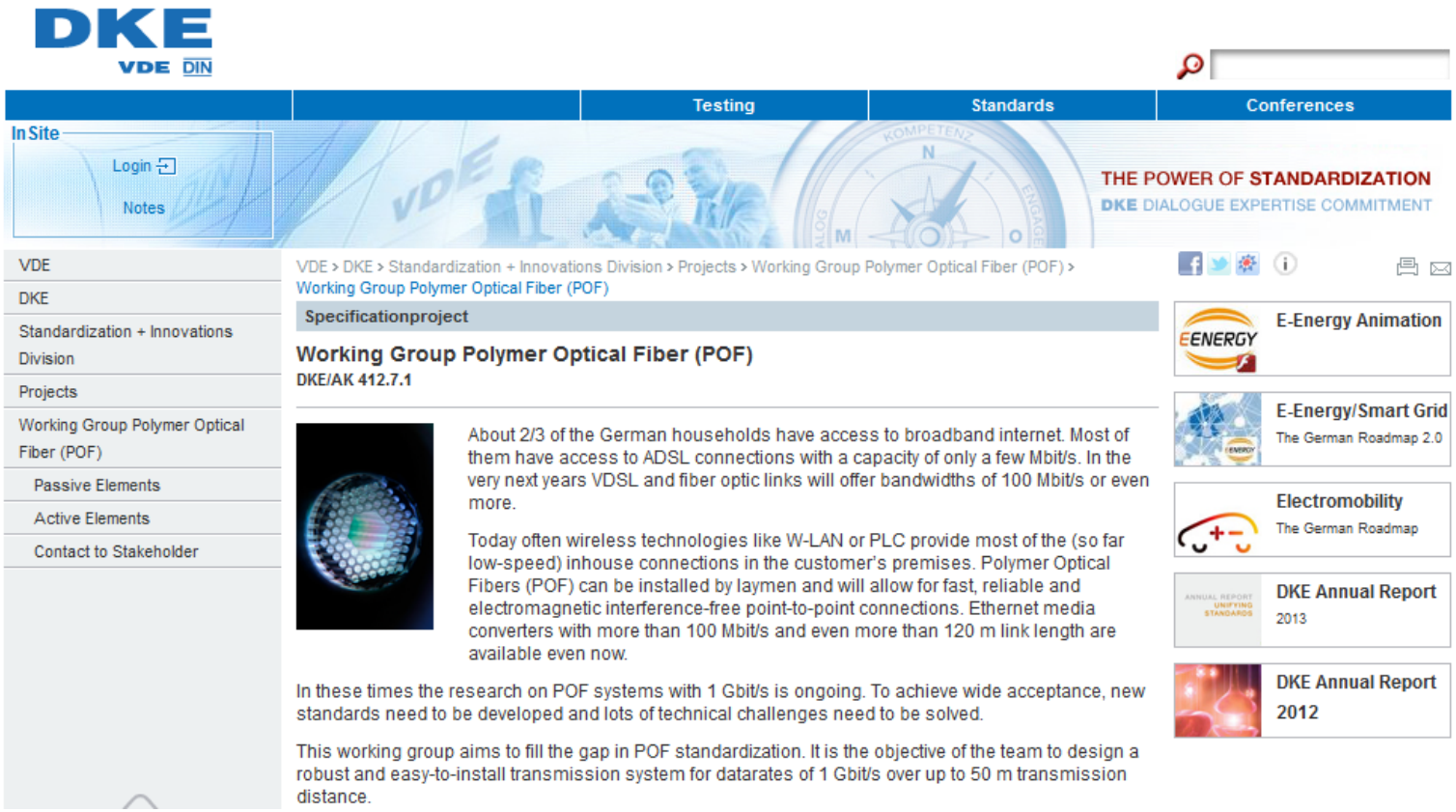
POF Working Group DKE/AK 412.7.1

- Firecomms subsequently participated in contributing to the physical layer specification of the POF Working Group in DKE/VDE



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Recent Availability of Green Edge Emitting Lasers

IEEE PHOTONICS TECHNOLOGY LETTERS, VOL. 24, NO. 3, FEBRUARY 1, 2012

Eye-Safe Data Transmission of 1.25 Gbit/s Over 100-m SI-POF Using Green Laser Diode

Roman Kruglov, Juri Vinogradov, Olaf Ziemann, Sven Loquai, Jens Müller, Uwe Strauß, and Christian-Alexander Bunge, *Member, IEEE*

***Abstract*— We report on 1.25-Gbit/s transmission over 100-m step-index polymer optical fiber (SI-POF) with 6.5-dB margin. Nonreturn-to-zero modulation with offline decision feedback equalization technique has been applied to an intensity modulated direct-detection optical channel. An edge emitting direct injection laser diode with 515 nm is used, which allows us to improve the system power budget due to a lower attenuation of the POF at this wavelength. The fiber-coupled optical power has been adjusted to 0 dBm which corresponds to eye-safety requirements.**

***Index Terms*— Green laser, interconnection, optical communication, polymer optical fiber, signal processing.**

I. Introduction

POLYMER optical fiber is a promising transmission media for in-house communication, short-range optical interconnects and industrial and car networks. The large-core diameter

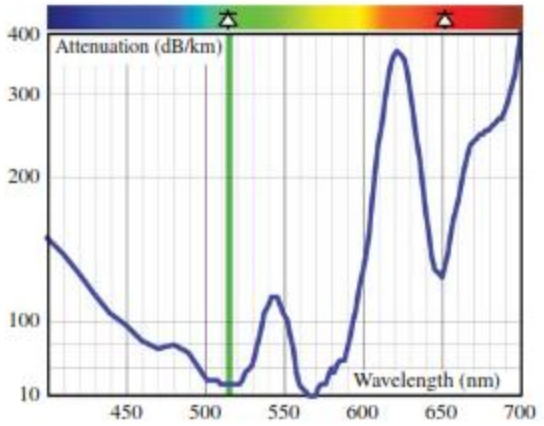

Fig. 1. Loss spectrum of PMMA SI-POF [1].

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Conclusions

- For long reach POF solutions both experiment and theory from the literature suggests that m-PAM is a good solution for GbE POF
  - Transmitter technology based on devices currently deployed and validated in Fast Ethernet transceivers
- Firecomms has commenced testing 16 PAM evaluation PCBs
- Possible road map to even longer distances and higher speeds with the advent of green semiconductor laser technology
- Firecomms willing to participate in the definition of a PHY specification