Basic Study about Bandwidth Requirement for Discrete Multi-tone Modulation

IEEE802.3 San Antonio Plenary, November, 2012

Toshiki Tanaka, Tomoo Takahara, Jens C. Rasmussen
Fujitsu Laboratories Ltd.
Supporters

- Song Shang (Semtech)
- Greg LeCheminant (Agilent technologies)
- Daniel Stevens (Fujitsu Semiconductor Europe)
- Hideki Isono (Fujitsu Optical Components)
- Hiroshi Hamano (Fujitsu Laboratories)
Background

- Previous presentation
  - Basic explanation of Discrete Multi-Tone (DMT)
  - Experimental results for 100GbE DMT

- This presentation
  - Basic simulation for optical 100GbE DMT
    - Bandwidth requirement
  - Discussion for device candidate

![Diagram](image)

(TIA: Transimpedance amplifier, TOSA: Transmitter optical subassembly, ROSA: Receiver optical subassembly)
Discrete Multi-tone (DMT) Technology

- Widely used in xDSL systems (ADSL, HDSL….)
  - High spectral efficiency and cost effectiveness
- Adaptive bit and power allocation for each subcarrier depending on transmission characteristics
- SNR measurement by using the probing signal
  - Modulation format of all subcarriers: QPSK
- Waterfilling algorithm from the SNRs of the transmitted probing signal
Simulation Platform

Modulator

Quantization (8 bits)

DAC model (64 GS/s)

Frequency response for DML (4th Bessel 8~26 GHz)

Noise loading (to emulate ENOB as 6 bits)

Frequency response for DAC (4th Bessel 25 GHz)

ADC model (64 GS/s)

S/P

Constellation mapping

IFFT

Adding Cyclic Prefix

P/S

DML (ideal)

SMF

PIN-PD (ideal)

Noise loading (SNR = 22 dB)

Frequency response for PIN-PD (4th Bessel 20 GHz)

Demodulator

Quantization (8 bits)

Frequency response for ADC (4th Bessel 25 GHz)

Equalization + Constellation demapping

FFT

Removing Cyclic Prefix

P/S

Quantization (to emulate ENOB as 6 bits)

Noise loading (to emulate ENOB as 6 bits)

ADC model (64 GS/s)
Simulation condition for DMT

- Subcarrier (SC) number: 256
- Baud rate per SC: about 125 MHz
- Cyclic prefix: 16
- Target BER: \(1 \times 10^{-3}\)

Example: SNR and bit allocation
Capacity: 127 Gbps
at 3-dB BW: 14 GHz

3-dB bandwidth of Tx (GHz)

Capacity (Gbps)

SNR (dB)

Bits

Subcarrier number
Discussion for Device Candidates

From the basic simulation, Tx bandwidth requirement is less than 14 GHz.

Transmitter (TOSA)

- Any devices used in modules for 10GbE-LR and 100GbE-LR4
  - 10-Gbps class TOSA: 10-Gbps class DML, 10-Gbps class EML
  - 25-Gbps class TOSA: 25-Gbps class DML, 25-Gbps class EML

  Driver amplifier has to be changed to linear amplifier.

Receiver (ROSA)

- Devices used in modules for 100GbE-LR4
  - 25-Gbps class ROSA: 25-Gbps class PD

- Receiver with narrower bandwidth than 20 GHz might be possible.
  - will check with simulation

  Limiting amplifier has to be changed to linear amplifier.
Example of Frequency Response

- 10-Gbps class DML

  - Vendor1
    - 30 mA
    - 60 mA
    - 3 dB down
    - 14 GHz

  - Vendor2
    - 80 mA
    - 50 mA
    - 3 dB down
    - 14 GHz

DMT modulation is tolerant of a non-ideal frequency response due to bit allocation for each SC with low baud rate
Summary

- **Basic simulation for optical 100GbE DMT**
  - Tx bandwidth requirement: less than 14 GHz

- **Discussion for device candidates**
  - Transmitter: 10-Gbps class DML, 10-Gbps class EML, 25-Gbps class DML, 25-Gbps class EML
  - Receiver: 25-Gbps class PD
    Narrow bandwidth receivers will be evaluated through simulation.

  ➢ Linear operation required for Tx and Rx amplifiers.
Thank you