

# Discrete Multi-tone Technology for 100G Ethernet (100GbE)

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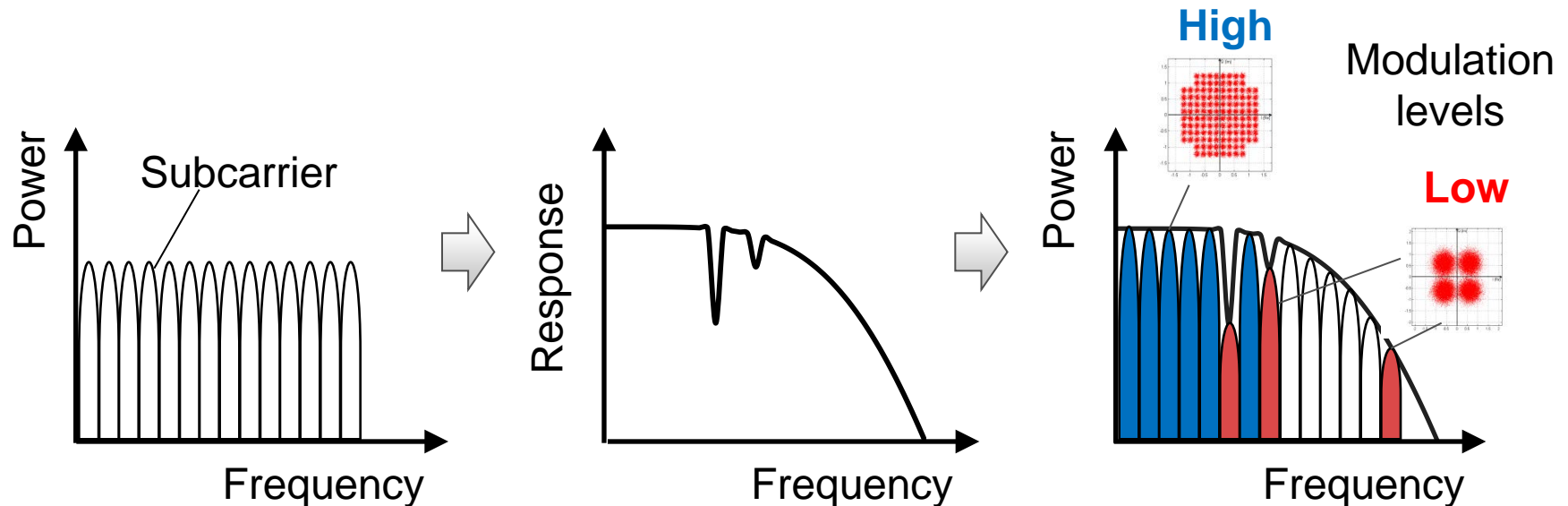
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# Outline

- Discrete multi-tone (DMT) technology
- First experiment of optical DMT
- Electrical 100GbE DMT
- Outlook towards 100GbE over optical DMT
- Summary

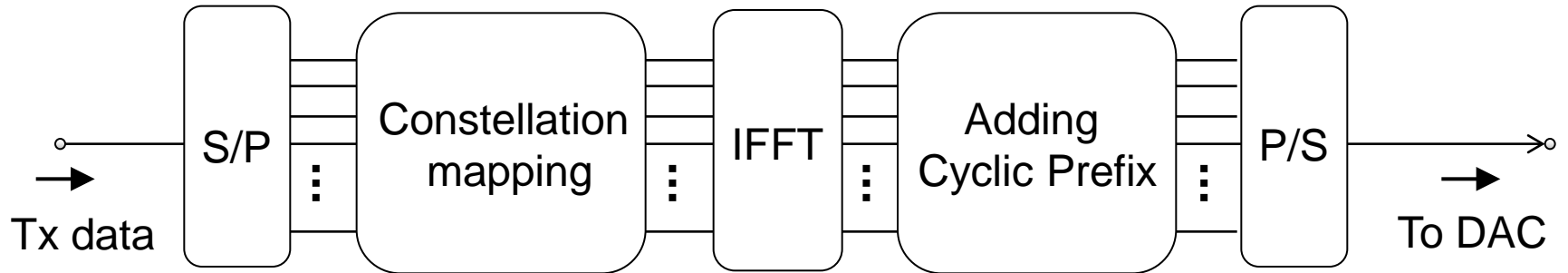
# Discrete Multi-tone (DMT) Technology

- 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

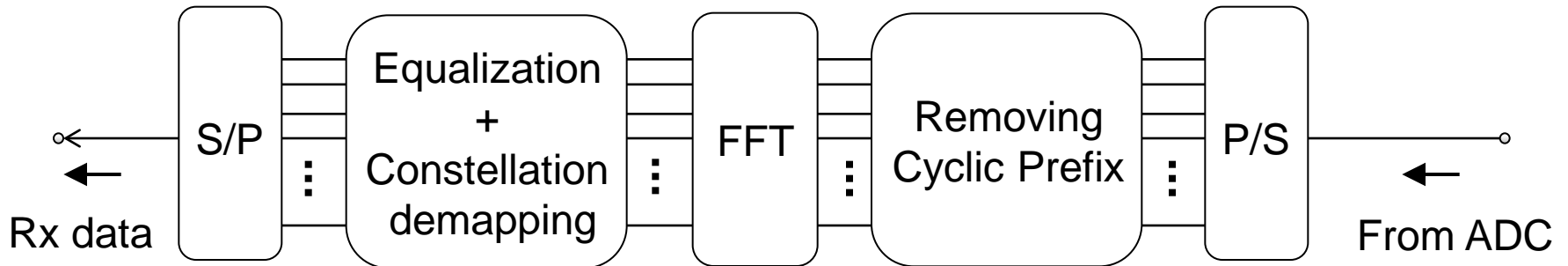


# Digital Signal Processing for DMT

## ■ DMT modulation



## ■ DMT demodulation



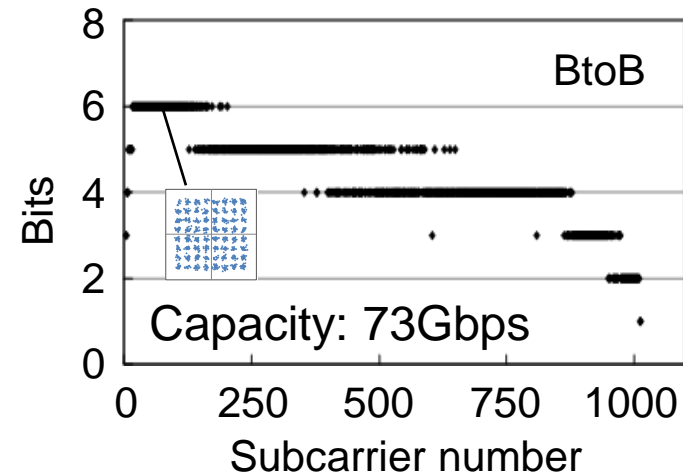
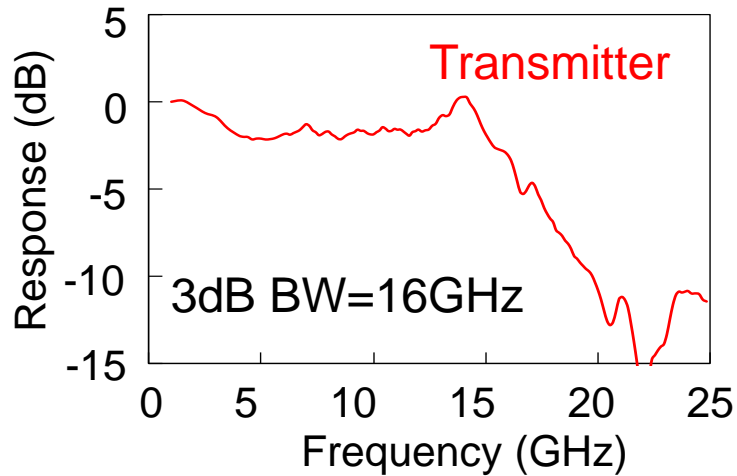
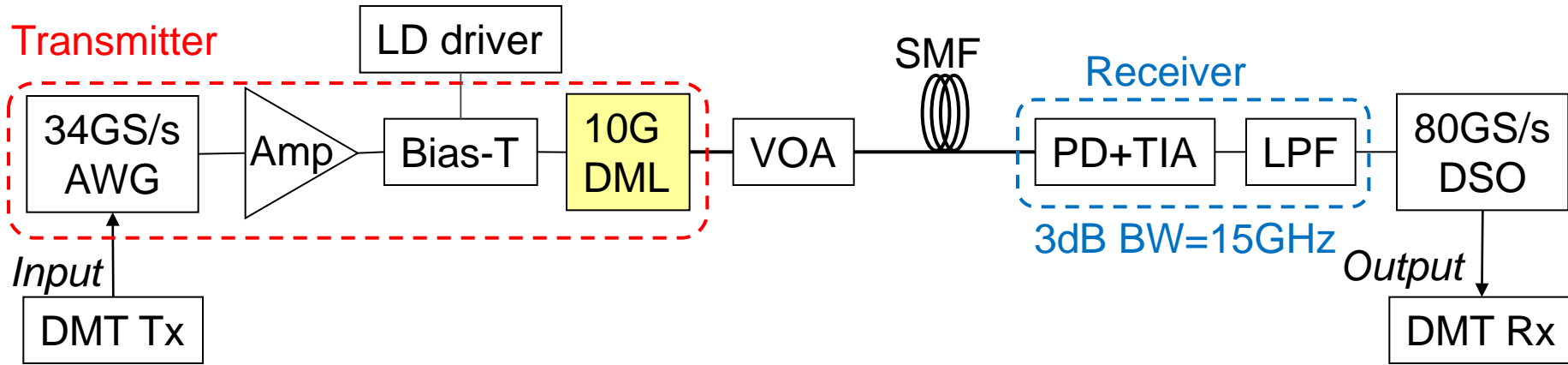
# Advantage of DMT Technology

- Reduction of required bandwidth due to high spectral efficiency by maximizing allocated bits
- Relaxation of specifications for shape of frequency response (ex.: amplitude and phase ripples) due to adaptive bit allocation for each subcarrier with low baud rate
- Low power consumption and simple configuration of LSI due to use of the technology studied in the development of the xDSL systems
- Available for optoelectronic devices with low cost and simple configuration because of single optics

**DMT is good candidate for 100GbE**

# First Experiment of Optical DMT

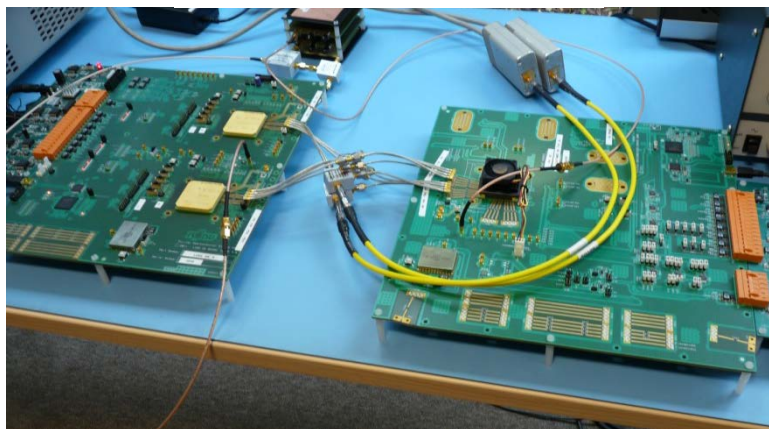
(Ref. T. Tanaka, et. al., OTh4G.3, OFC2012.)



Frequency characteristics of DAC were not sufficient to achieve 100GbE.

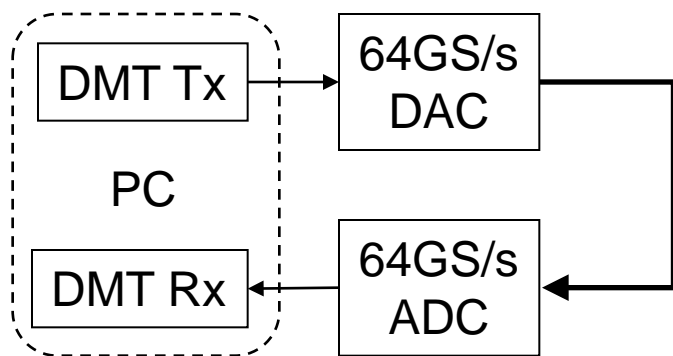
# Electrical 100GbE DMT

## Experimental setup

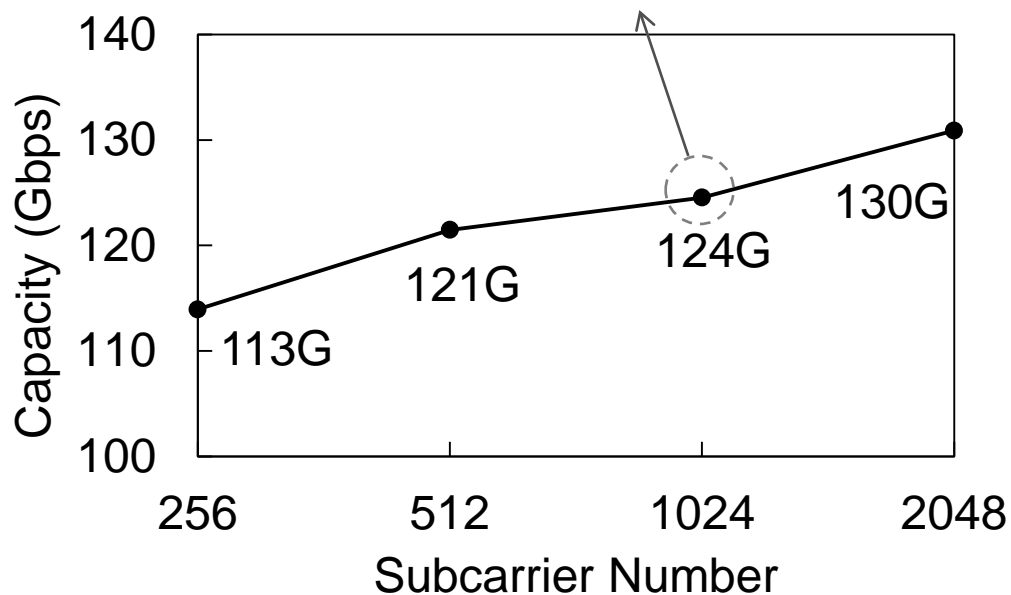
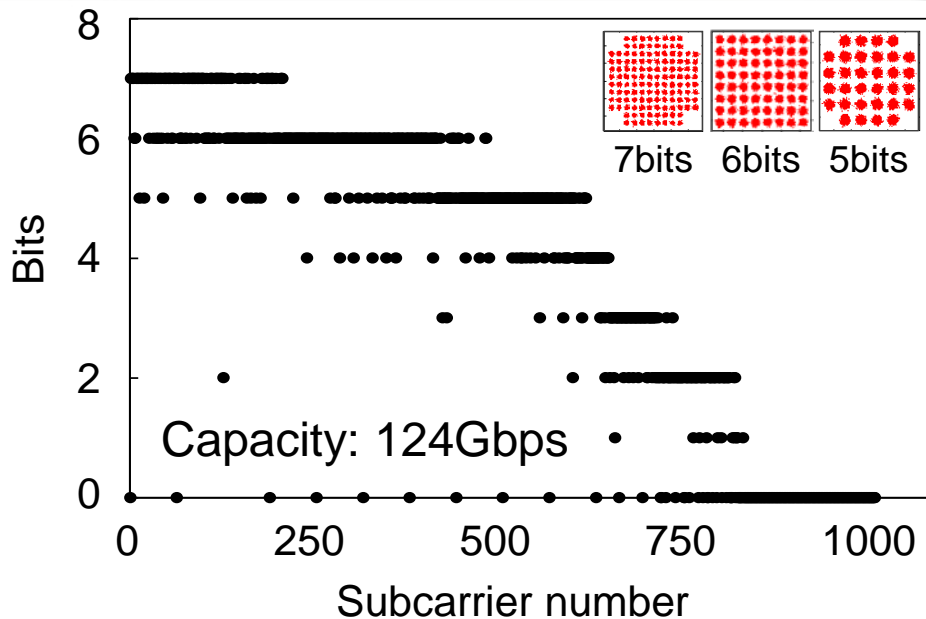


FSEU 64GS/s  
ADC (Luke)

FSEU 64GS/s  
DAC (Leia)



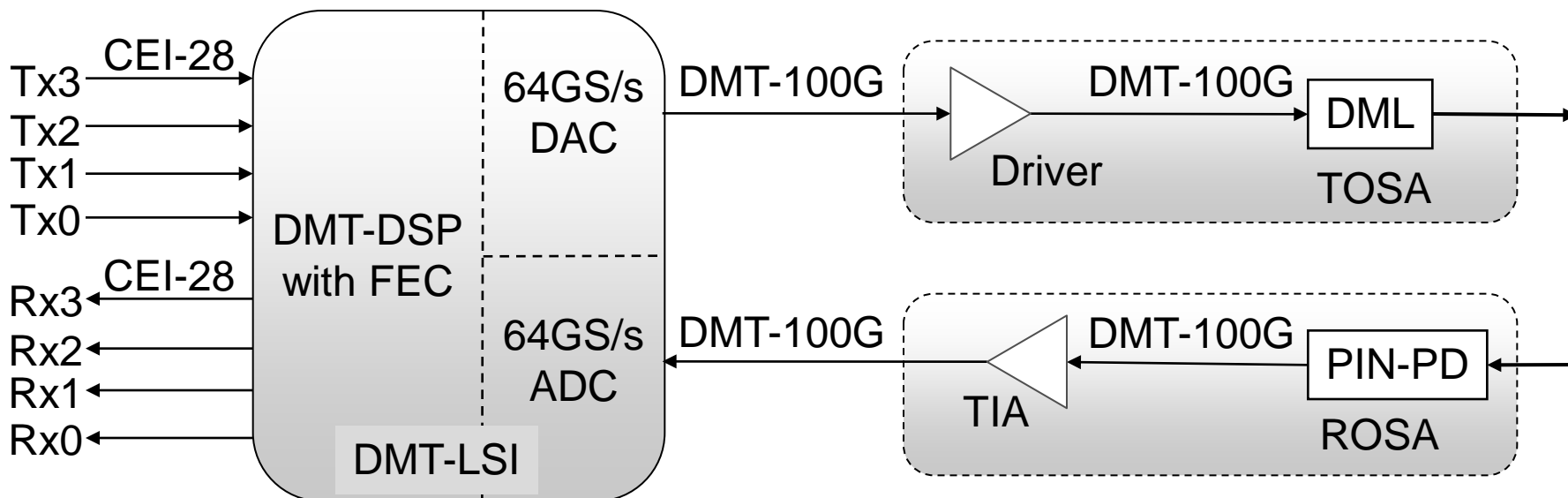
Electrical BtoB



# Outlook towards 100GbE over Optical DMT

- Characteristics improvement of DAC and ADC
  - Increase of effective number of bits
  - Enhanced bandwidth

## 100G block diagram





# Summary

- Introduced DMT modulation technology
- First experimental demonstration of DMT with optical channel
- Experimental demonstration of electrical 100GE DMT
- Outlook for optical 100GE DMT

Thank you