A Multilevel Modulation Scheme for High-Speed Wireless Infrared Communications

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Motivation

- A high data rate, short distance link is required to connect portable devices to:
  - backbone network, data storage, user interface peripherals, other portable devices …
- Possible Solutions :
  - Mechanical connection
  - RF wireless link
  - Optical wireless link

Why Wireless Infrared ?

- Advantages of Wireless IR links :
  - high data rate
  - unregulated bandwidth
  - lower cost
  - flexible interface
  - small form factor
- Constraint :
  - need to use inexpensive optical devices

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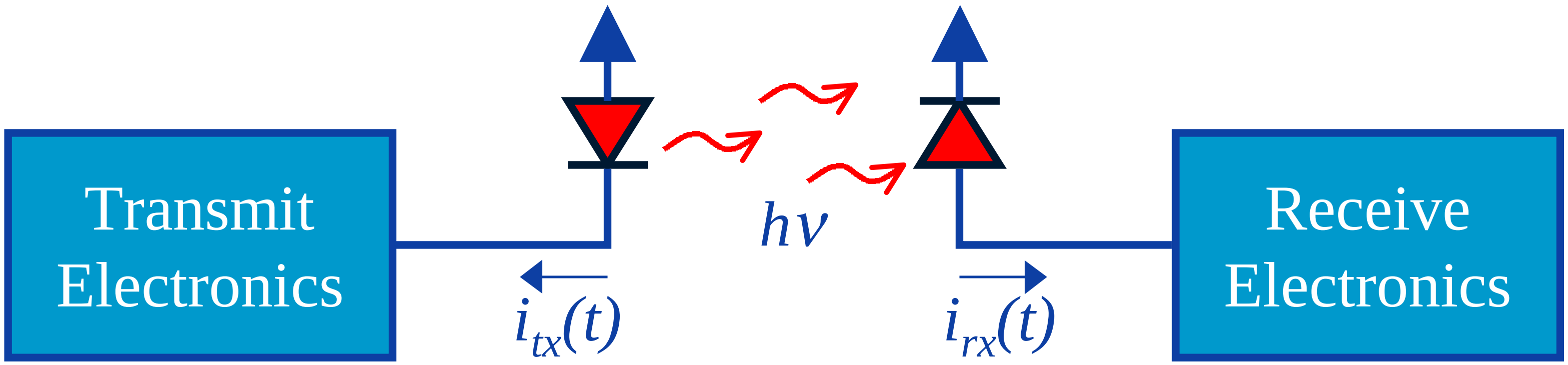
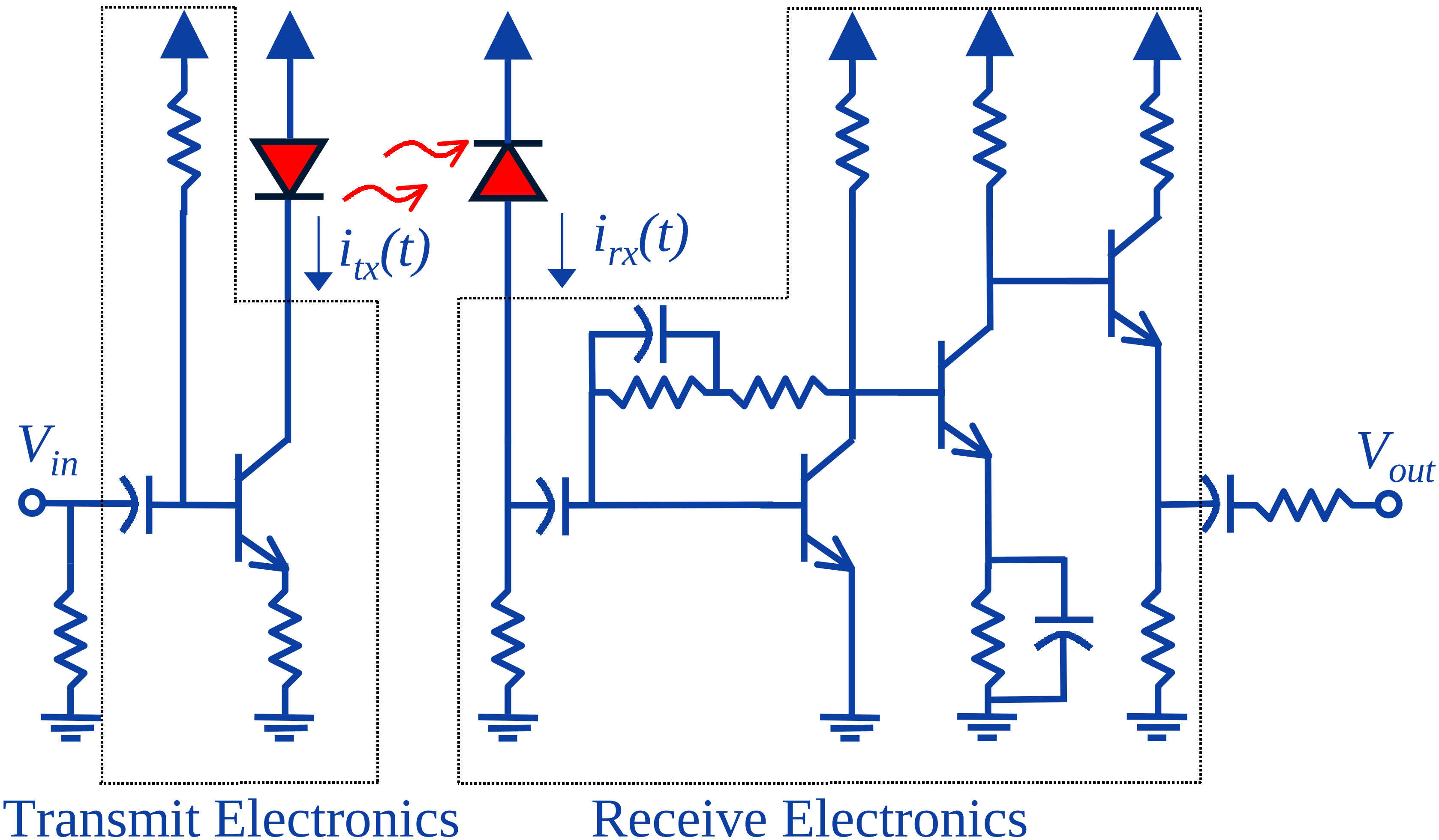
Basic Channel Structure

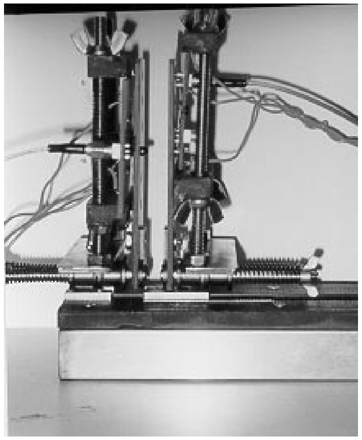


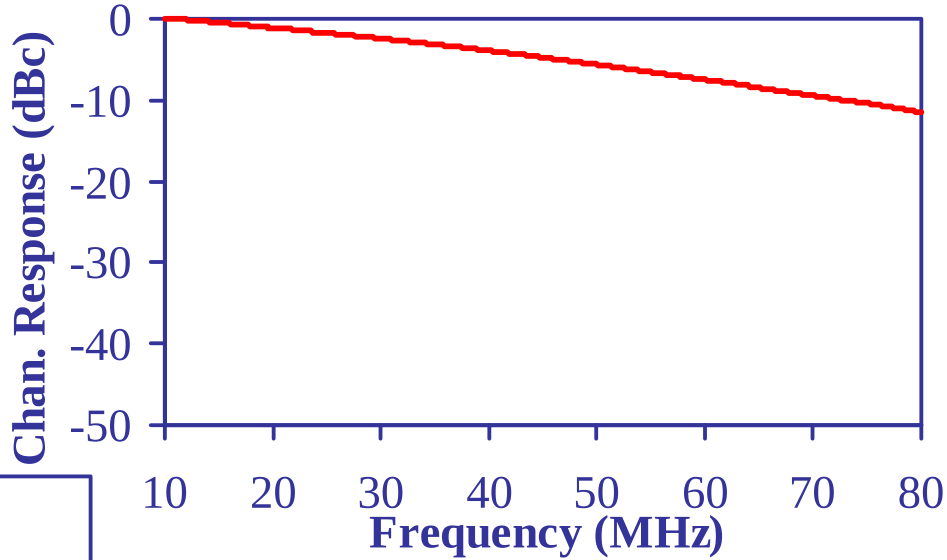
- LED emits incoherent light over a wide spectrum.
- Photodiode is linear over a wide input range.

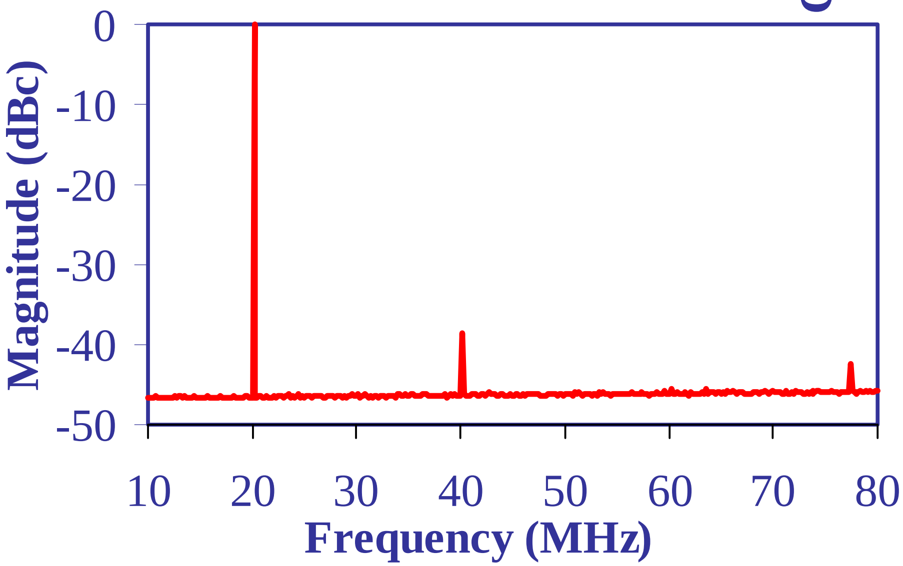
Experimental Link



Experimental Results







- Results
  - Bandwidth : 35 MHz
  - SFDR : 20 dB

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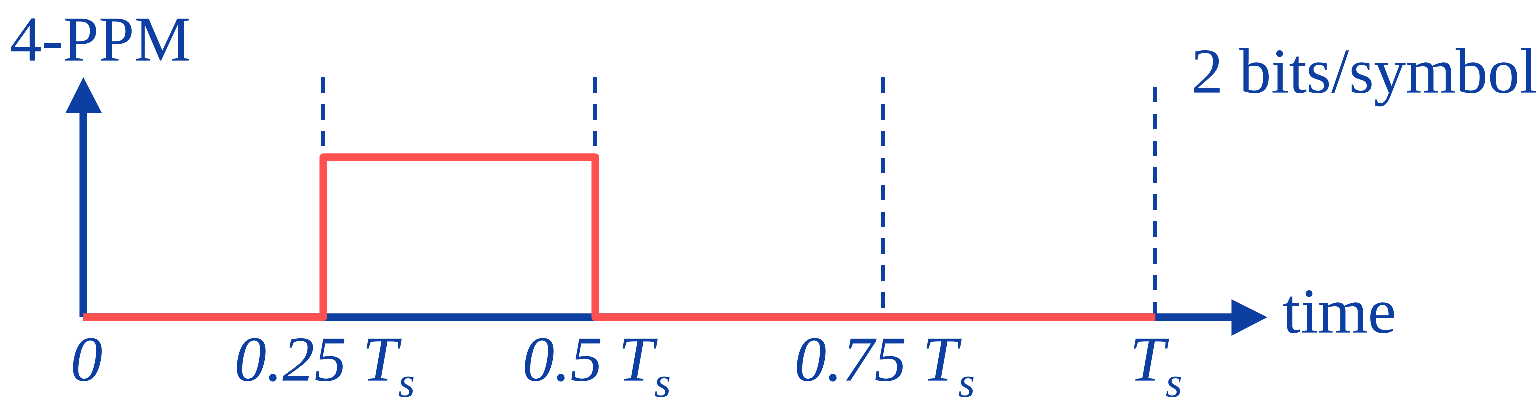
Channel Constraints

- Physical channel constraints :
  - signals must remain non-negative
  - average output signal fixed for eye safety

- Practical channel limitations :
  - bandwidth of channel is limited
    - need bandwidth ***efficient*** modulation schemes for higher data rate transmission.

Conventional Optical Modulation Techniques

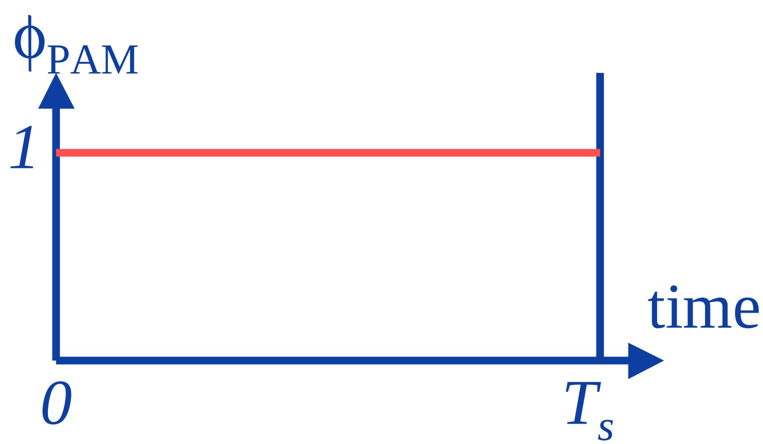
- Schemes based on pulse transmission
  - on-off keying
  - pulse position modulation (PPM)

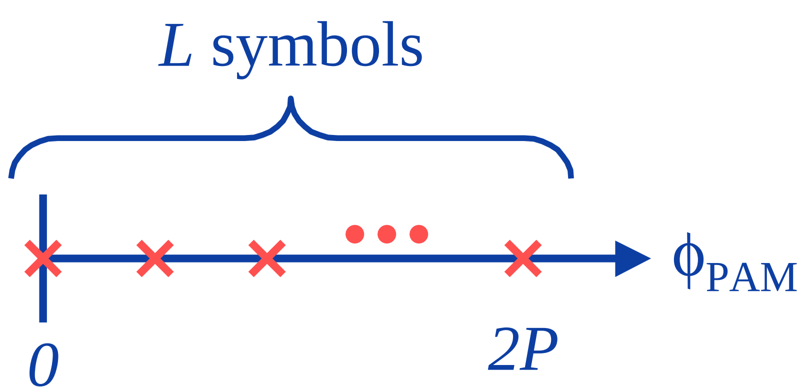


- Well suited to optical fibre applications.

Pulse Amplitude Modulation (PAM)

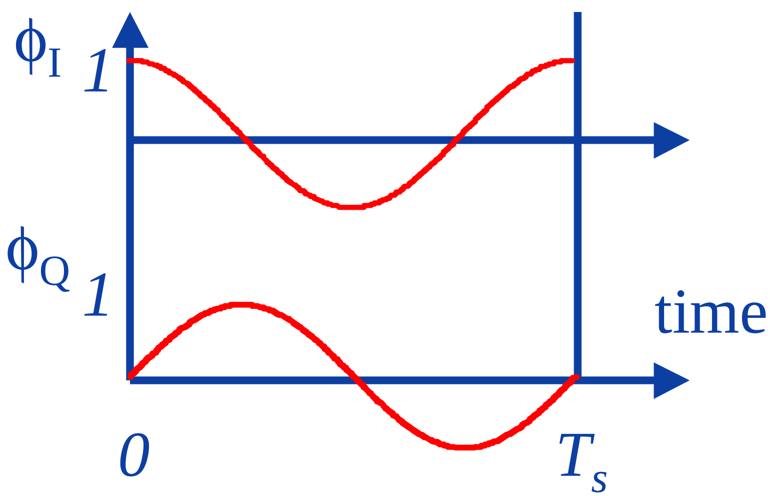
- In each symbol interval, pulse assumes one of *L* non-negative levels.
  - non-negativity guaranteed.
  - average optical power set by symbol distribution.

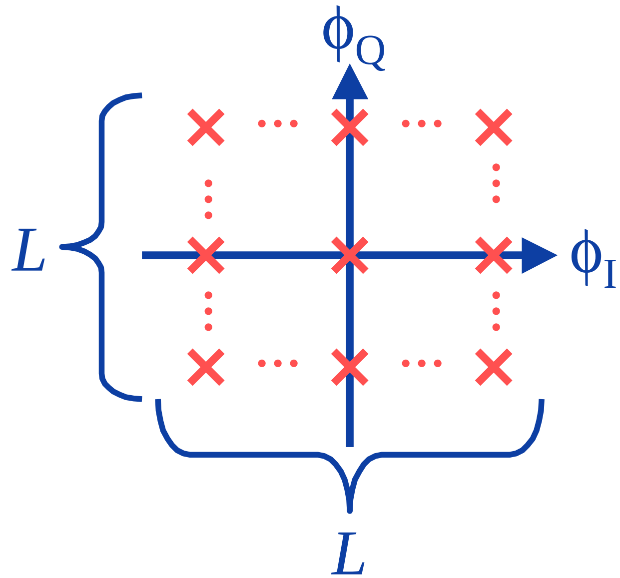




Quadrature PAM (QAM)

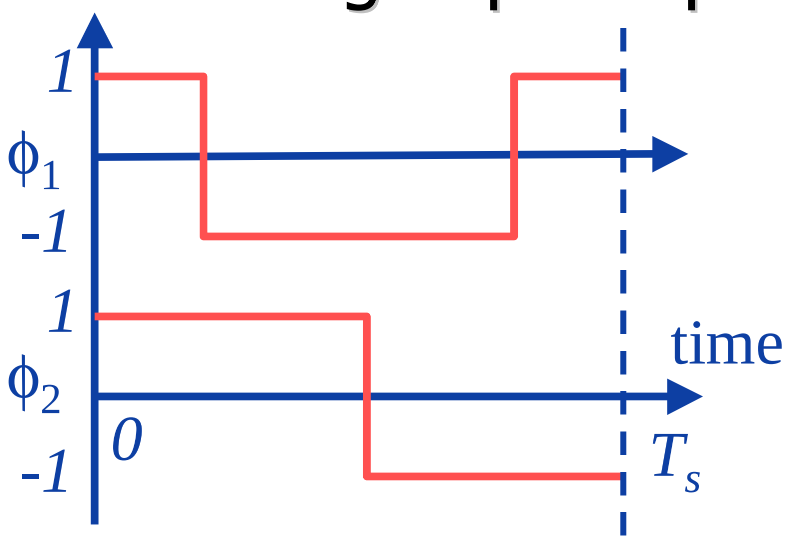
- Two *L*-PAM signals on quadrature carriers
  - fixed DC bias added to each symbol to ensure non-negative output
  - average optical power independent of data

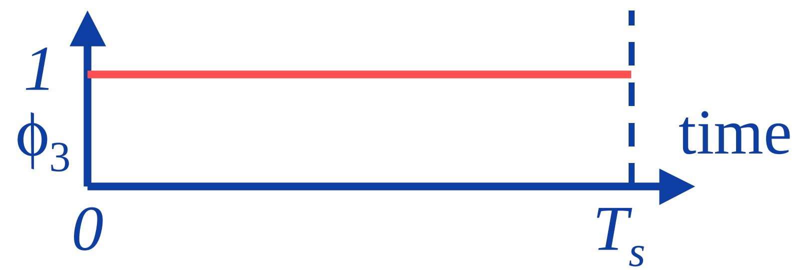




Adaptively-Biased QAM (AB-QAM)

- L^2-QAM with square wave carriers
  - adaptive DC bias is added to each symbol to satisfy non-negativity constraint
  - average optical power set by data distribution





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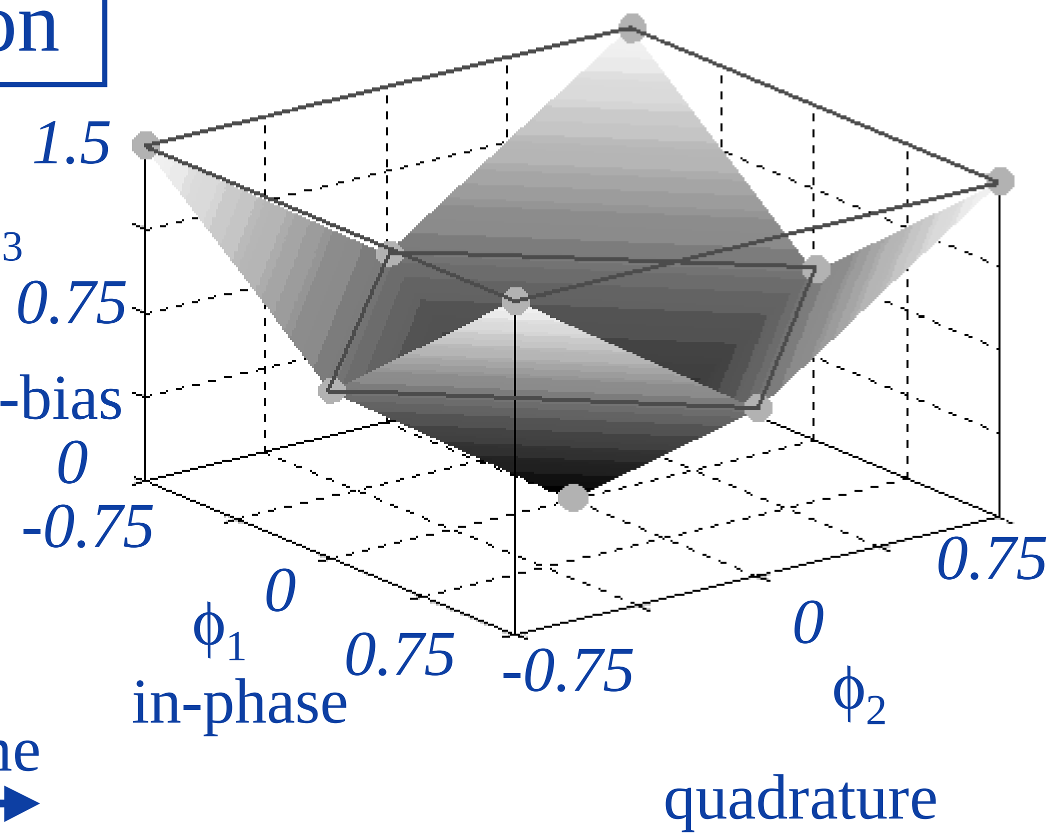
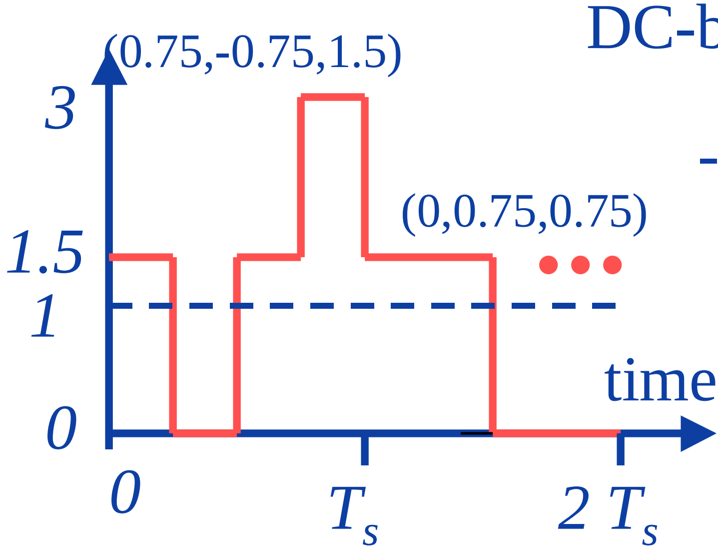
Example : 9-AB-QAM

Constellation



Time-Domain



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AB-QAM Key Points

- Achieves an asymptotic 3dB optical SNR improvement over PAM by :
  - minimizing the amount of bias to optical signal
  - using information in symbol average :
    - SIGNAL SPACE DIVERSITY

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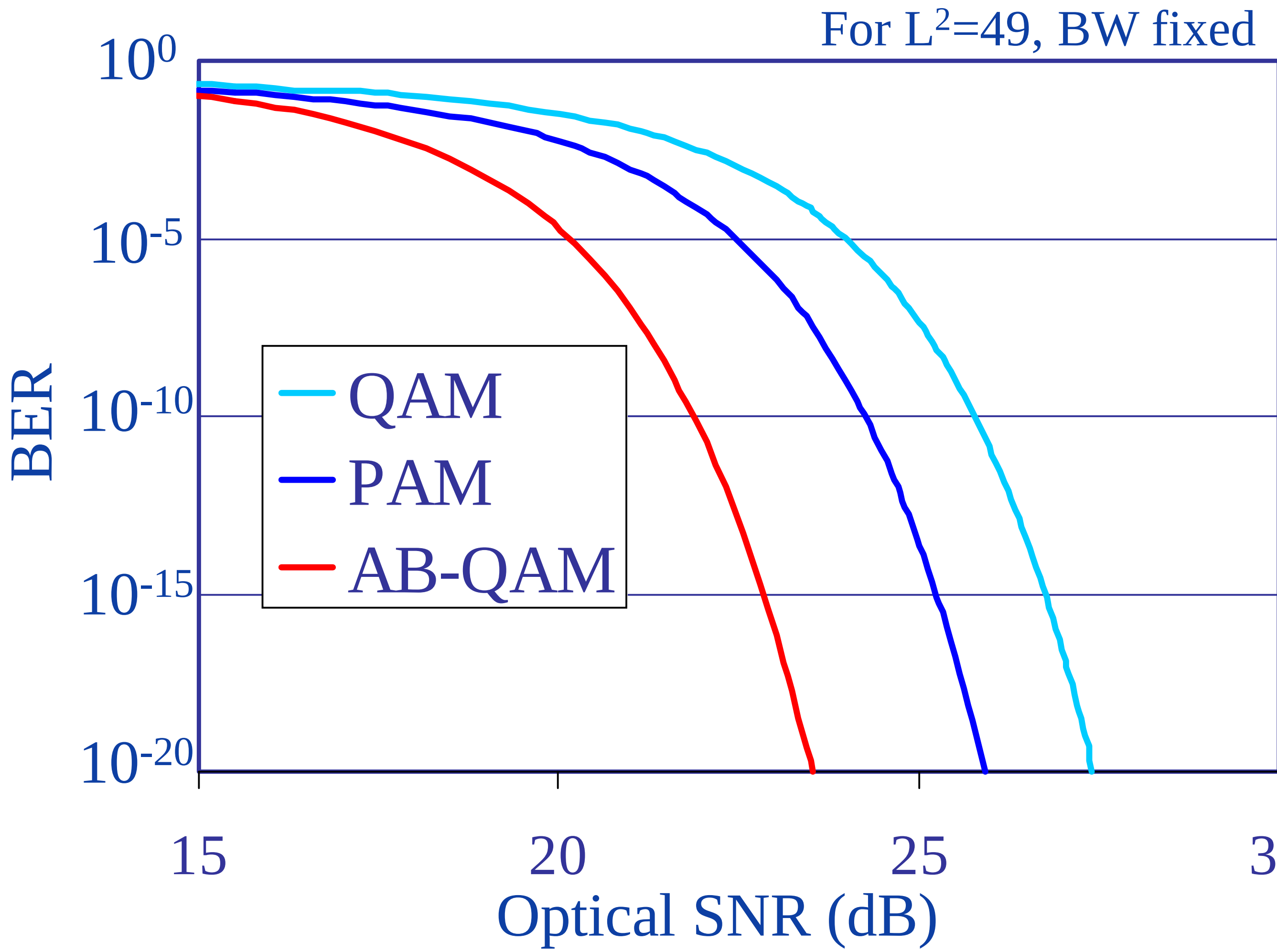
Simulation Results



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Conclusions

- Multilevel modulation schemes are necessary for next generation, short distance, high-speed wireless infrared links.

- AB-QAM provides a 3dB optical SNR gain over PAM, while maintaining the same bandwidth efficiency.