Optical Wireless -Optical indoor communication systems

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Introduction

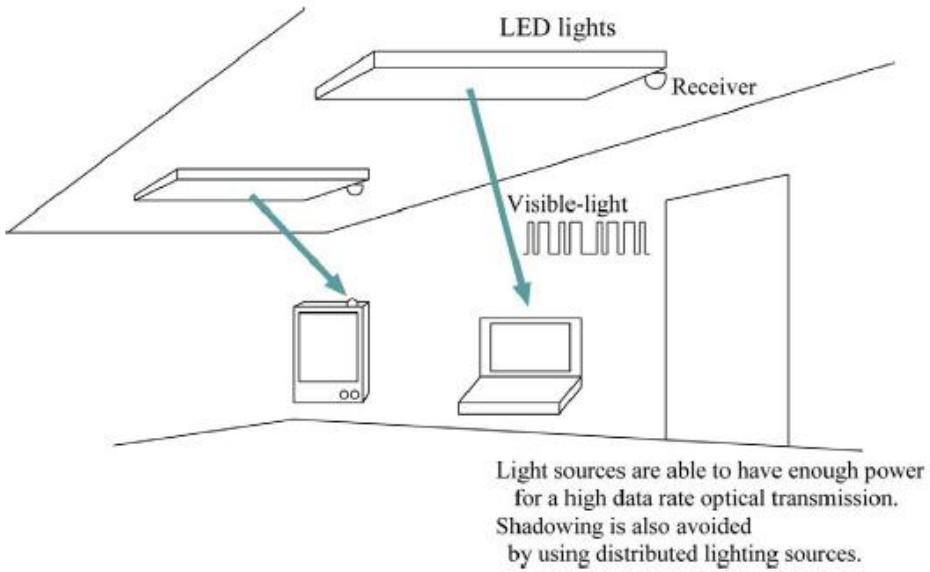
- An optical wireless communication (OWC) system relies on optical radiations to convey information in free space, with wavelengths ranging from infrared (IR) to ultraviolet (UV) including the visible light spectrum. Especially for indoor scenarios, like office and home environments, OWC can provide significant spectrum relief for the crowed radio frequency (RF) spectrum used by traditional wireless communications.

Current status

- Over the decades, the interest in OWC remained mainly limited to covert military applications, and space applications including inter-satellite and deep-space links. OWC's mass market penetration has been so far limited with the exception of Infrared Data Association (IrDA) which became a highly successful wireless short-range transmission solution. With the growing number of companies offering terrestrial OWC links in recent years and the emergence of visible light communication (VLC) products the market has begun to show future promise

Optical indoor systems

- Transmitter
- Receiver
- Channel



- Transmitter

- Light-emitting diodes(LEDs)
- Laser Diodes(LD)

LEDs

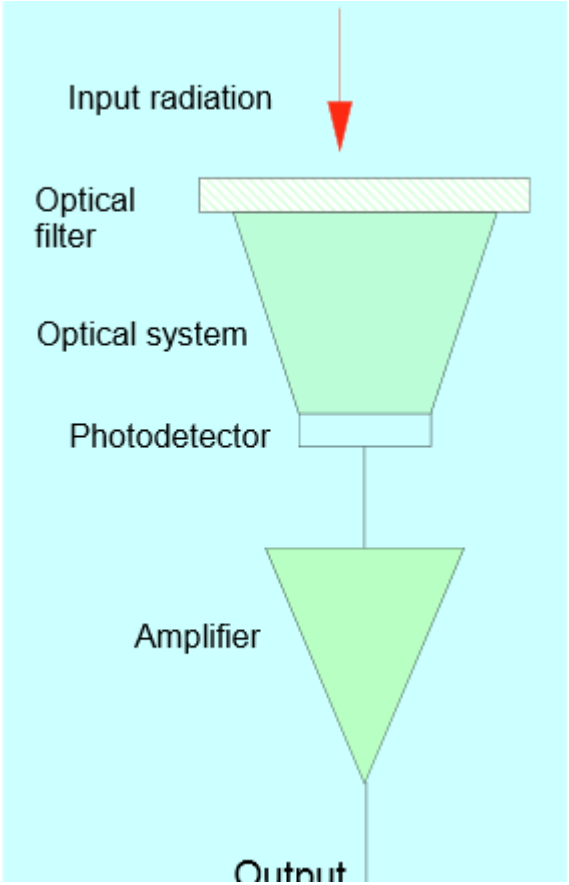
- Incoherent light
- Inefficient
- Low-cost

Laser Diodes

- Coherent light
- Efficient
- Costly

Optical receiver

The receiver/detector converts the optical power into electrical current. Optical filter rejects 'out of band ' ambient illumination noise. Lens system or concentrator collects and focuses radiation. Photodetector (or array of detectors) converts optical power to photocurrent .It has Incoherent detection. Amplifier determines system noise performance .

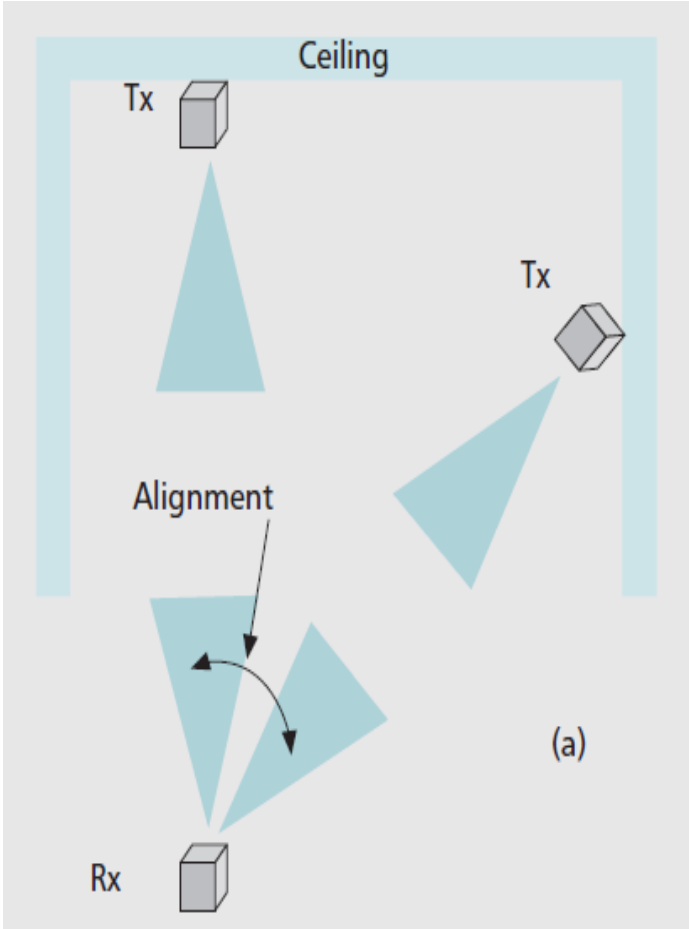


Optical Channels

- Directed Line of sight(LOS) link
- Non-directed LOS link (diffuse link)

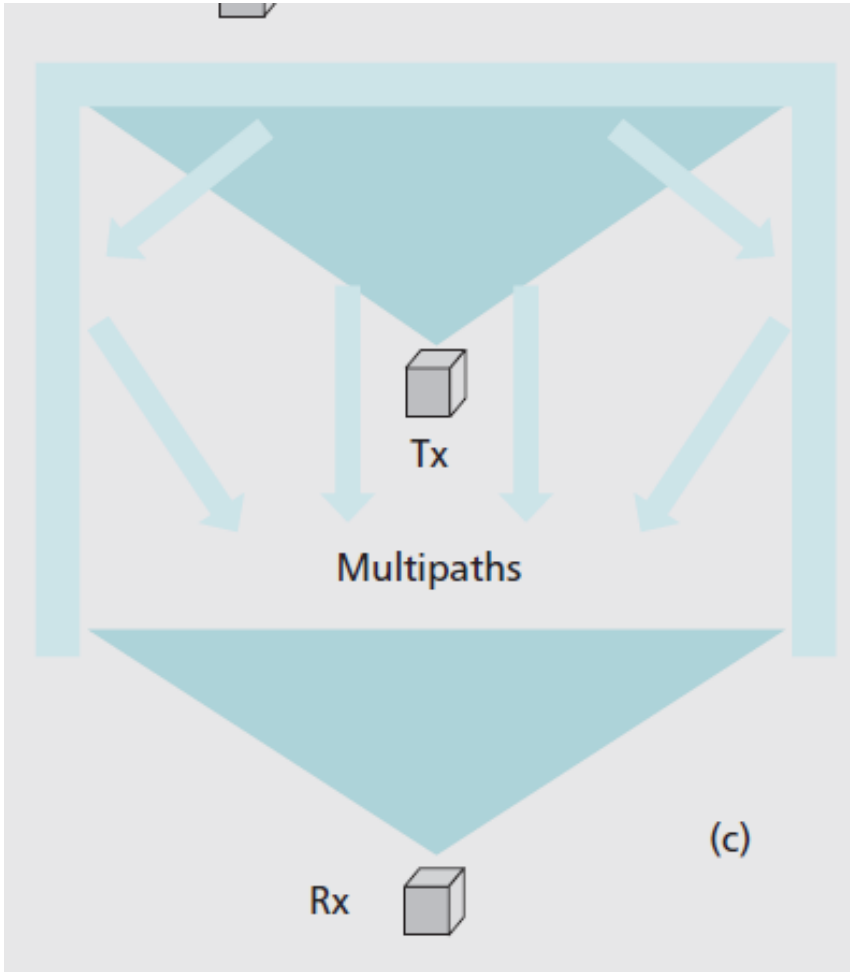
Directed Line of sight(LOS)

- The direct line of sight configuration requires alignment between the transmitter and receiver to establish communication by transmitting optical signals from the transmitter to the receiver without any reflection.



Non-directed LOS link(diffuse link)

- Does not require the alignment of transmitter-receiver in which the transmitters send optical signals in a wide angle to the ceiling and arrive at the receiver after one or several reflections



- Directed LOS:
- Maximal power efficiency
- Less power loss
- Limited transmission angel
- Blocked by obstacle
- Non-directed LOS:
- Low power efficiency
- Link is always maintained between the transmitter and the receiver.
- More practical

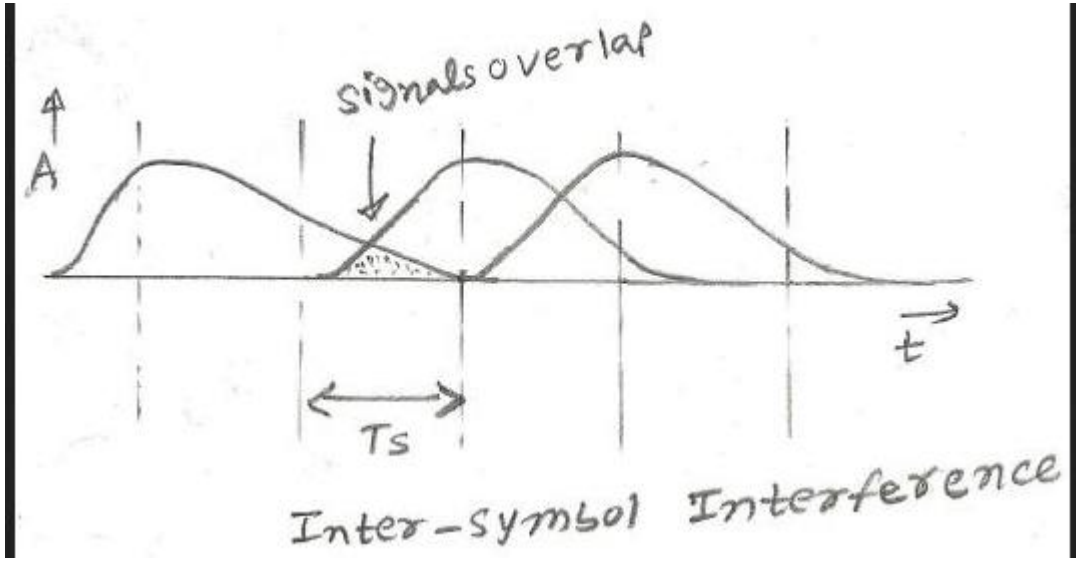
Optical Indoor Signals Modulation

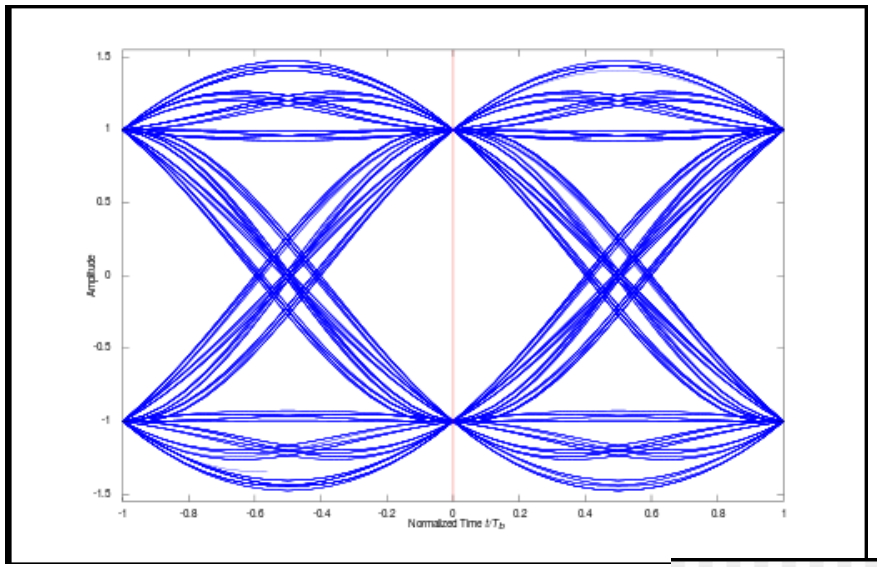
- Intensity modulation and Direct Detection (IM/DD)
- Orthogonal frequency-division multiplexing(OFDM)
- Multiple-in-multiple-out(MIMO) system

IM/DD

- Intensity modulation is a form of modulation in which the optical power output of a source is varied in accordance with some characteristic of the modulating signal.
- Direct detection using photodetector to demodulate and convert the analog signals into digital.

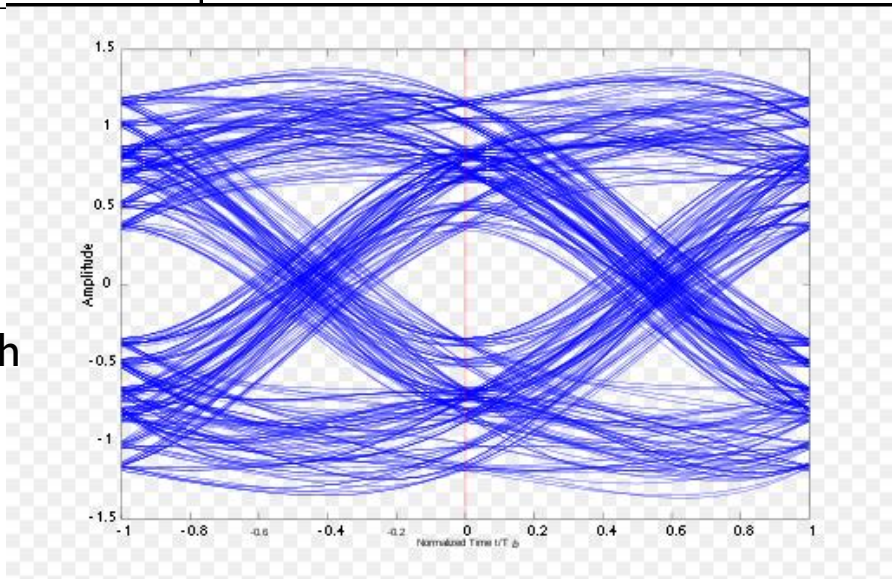
- In a diffuse OW system , several paths from source to receiver exist, which makes the system robust to blockage/shadwoing. However, the path losses are high and multipaths create intersymbol interference (ISI) which limits the achievable data rate and makes the communication less reliable.


signals overlap
A
t
Ts
Inter-symbol Interference



The eye diagram of a binary PSK system

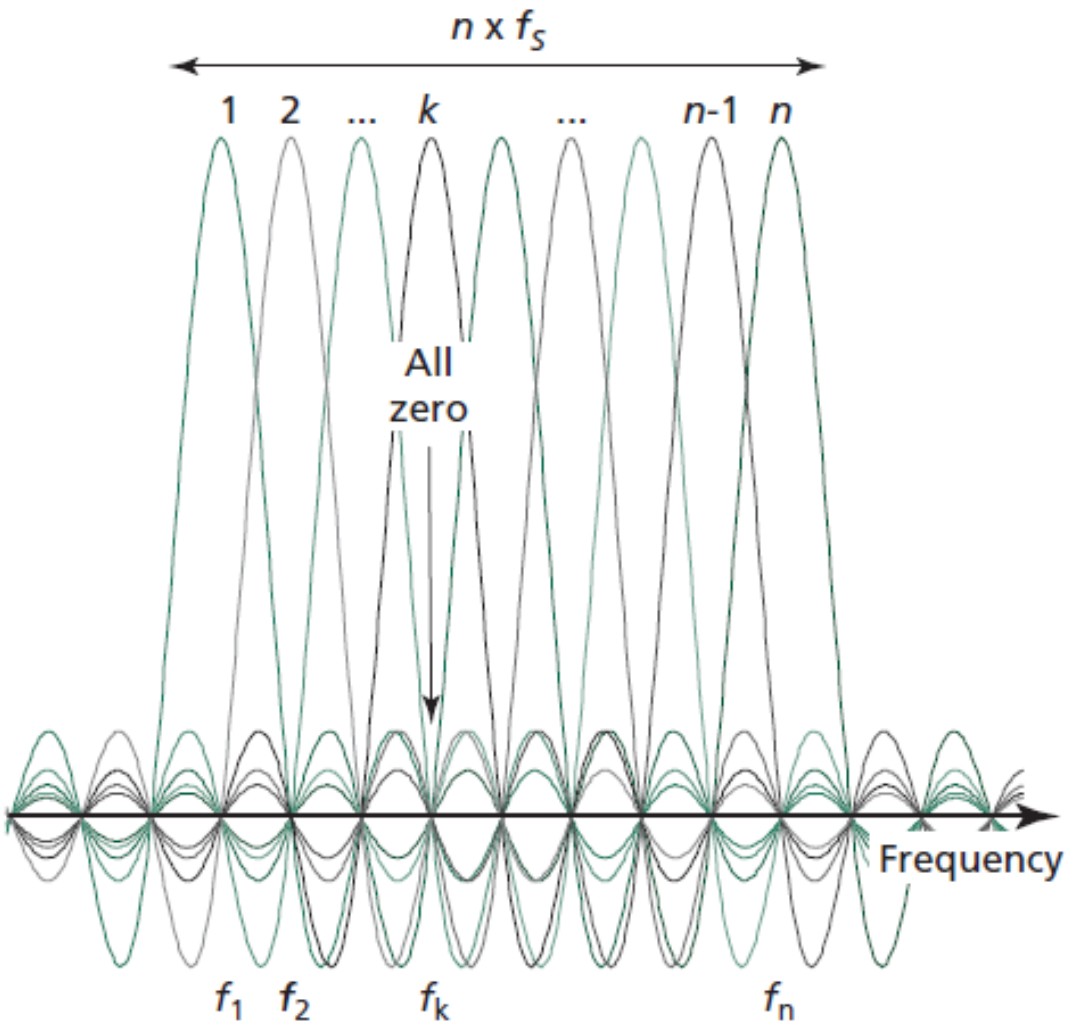
The eye diagram of the same system with multipath effects added



OFDM

- **Orthogonal frequency-division multiplexing** (**OFDM**) is a multi carrier modulation scheme, where the individual modulated subcarriers are transmitted in a multiplexed setup in parallel.

- If the subcarriers are shifted close together in frequency domain to achieve the highest spectral efficiency, the independence or orthogonality of the subcarriers is required. Then all subcarriers may overlap, but, at the frequency of the *nth subcarrier, the* power of all other subcarriers is zero.



OFDM—Orthogonal frequency division multiplexing

MIMO

- Multiple-Input Multiple-Output (MIMO) systems are widely used in Radio Frequency (RF) communications ,including for example the latest generation of wireless LAN standards (802.11(n)). By spreading the total transmit power over the transmitters to achieve an power gain that incrementally improves the spectral efficiency (more bits per second per hertz of bandwidth

- This figure shows a generic MIMC system, with a number of transmitting (sources) and receiving(detectors) antennas.

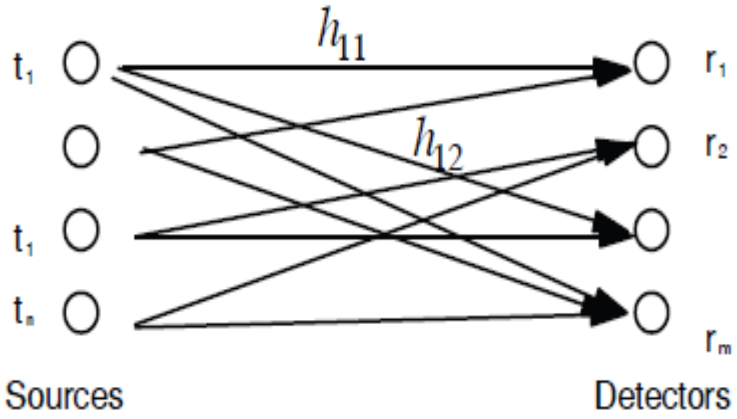
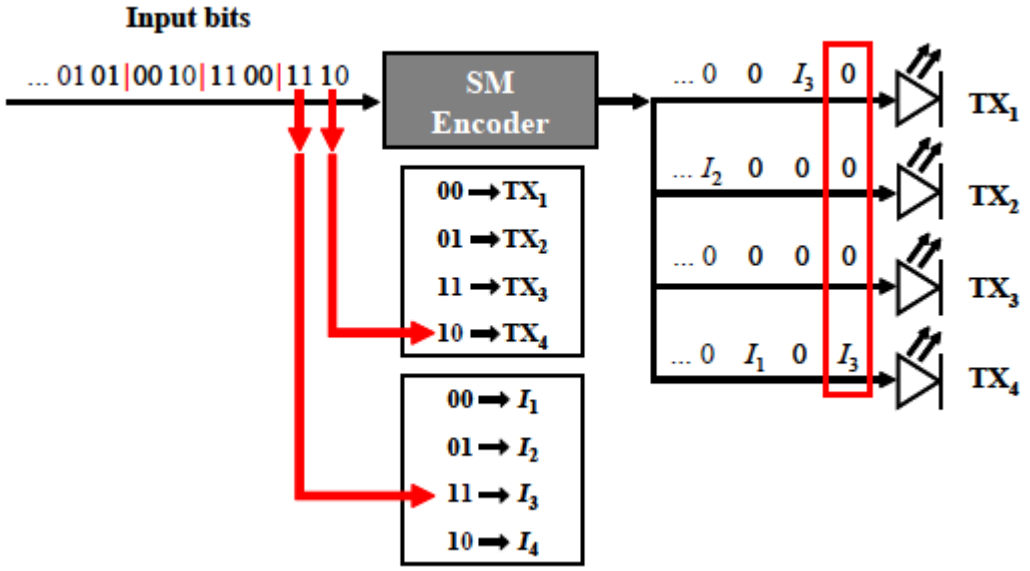


Figure 1. MIMO system

MIMO-spatial modulation(SM)



- This figure is the illustration of SM operation.
- The first two bits in the block of four bits determine the PAM symbol and the second twobits determine the active LED.

- SM simultaneously transmits data in the signal domain and the spatial domain.
- As only one transmitter is activated at any symbol duration, SM completely avoids inter-channel interference (ICI).