Infrared Channels

Prof. David Johns
University of Toronto

(johns@eecg.toronto.edu)
(www.eecg.toronto.edu/~johns)

Infrared Channels

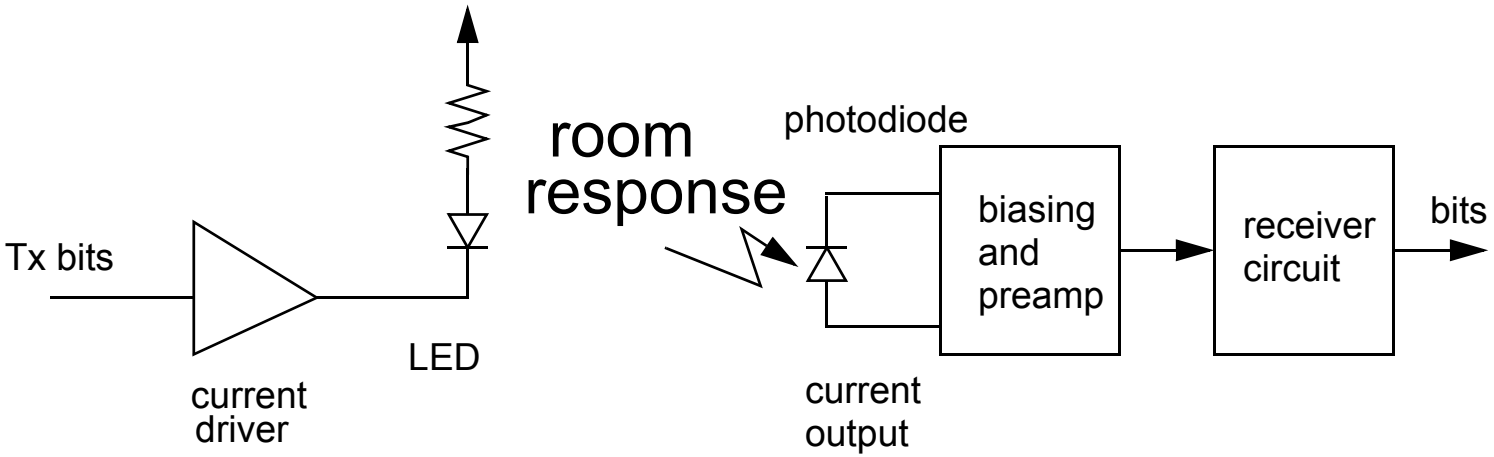
Advantages

- Free from regulation, low cost
- Blocked by walls — reduces eavesdropping and inter-cell interference
- Abundance of bandwidth in directed line-of-sight
- **Disadvantages** — lower range and bandwidth than radio

Types of Links

- Line-of-sight (does not rely on reflections) — higher bandwidth, easily blocked
- Diffuse (disperse Tx and wide-angle Rx) — lower bandwidth, very tolerant to shadowing

Infrared Channels



Transmit LED

- GaAs LED emission match peak of silicon photodiode sensitivity (850 nm wavelength)
- 10-20% efficient — transmit current up to 0.5A
- Laser diodes also used — 30-70% efficient
- Laser diodes must be rendered eye-safe — diffuser

Receive Photodiode

- Reverse-biased — light creates electron-hole pairs in depletion region
- R is responsivity of diode — 0.6 implies 60% of photons collected result in current flow
- Optical filters and concentrators can be used (reduces required size of photodiode)
- Usually off-chip photodiode used since received power is proportional to photodiode area
- Large photodiode results in large diode capacitance
- Large input dynamic range (perhaps 100 dB) required.

Infrared Channels

Eye safety

- Need to limit optical power for eye safety
- Optical power proportional to Tx signal current
- Receive signal current proportional to optical power
- Optical power proportional to ***square*** of receive signal power
- Makes design different that conventional channels

Example

- 10 dB loss in optical power ($100\mu W \rightarrow 10\mu W$)
- 20 dB loss in Rx current ($100nA \rightarrow 10nA$)
- If noise remains unchanged, twice dB loss
- Reason for low range operation

Noise

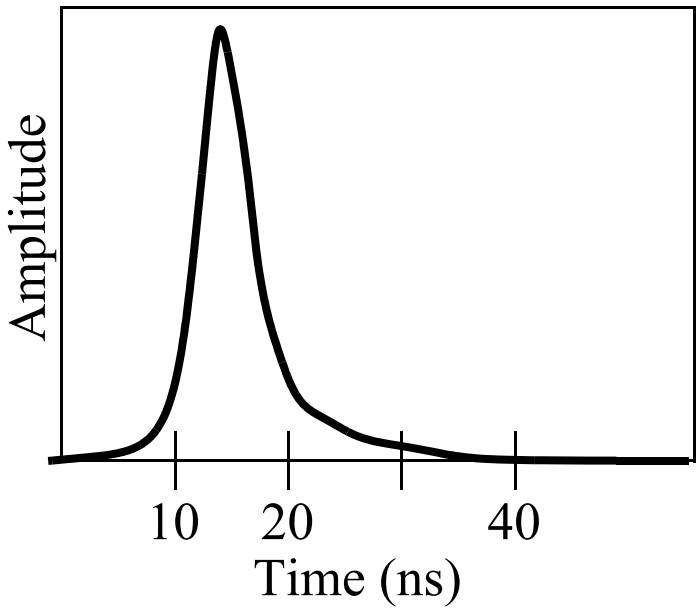
- Ambient light typically much larger than infrared light resulting in a large dc bias Rx current
- Main source of noise — shot noise from ambient light on photodiode
- Modelled as white but can be shaped by preamp (increases at higher freq)
- Independent of Rx signal
- Also noise from fluorescent lamp ballasts — 20kHz and harmonics
- Fluorescent lamp noise likely to become worse as ballast frequencies increase

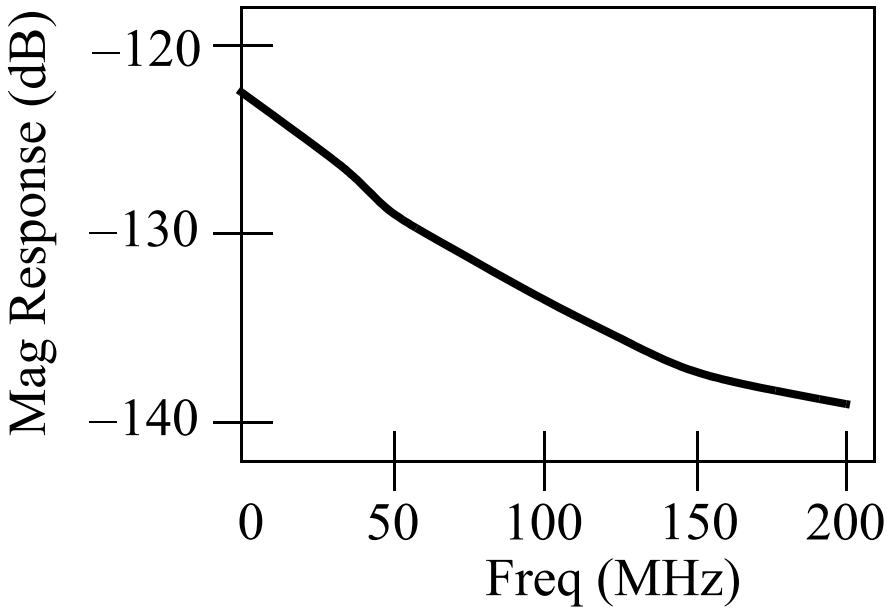
Diffuse Channel

- Infrared behaves same as visible light
- No worry about multipath fading since wavelength is so small.
- Multpath dispersion does exist and limits channels to 10-50MHz
- Most reflective walls are modelled as Lambertain reflectors — incident light re-radiated in all directions
- Results in multipath that is hard to shadow
- Results in time-dispersion (i.e. lowpass filtering)
- Use an LED with spatial dispersion
- Use photodiode with optical filter + concentrator

Diffuse Channel

- Typical room responsel

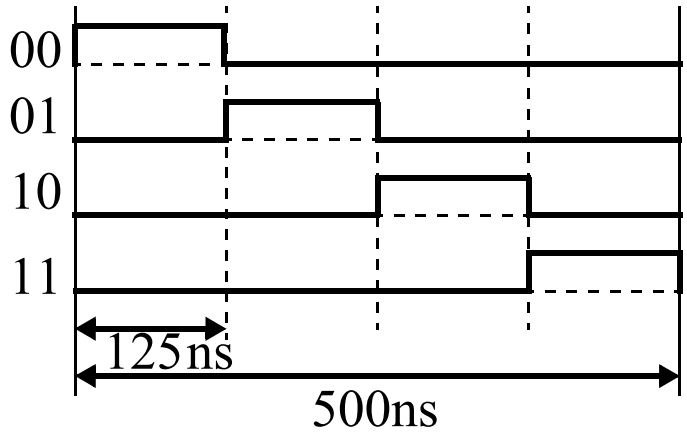




- Diffuse system with no LOS
- Rolls off steadily at high frequencies

Pulse-Position Modulation

- In 1993, IrDA (Infrared Data Association) formed
- 4.0 Mb/s standard uses 4-PPM



- Type of orthogonal modulation
- In general, L-PPM has each symbol having L time slots
- Power transmitted in one time slot and zero otherwise

Pulse-Position Modulation

Advantage

- Average power requirement decreases with increasing L

Disadvantages

- Higher bandwidth required
- Increased peak-power requirement
- Requires both time-slot and symbol-level synchronization

Soft-Decoding

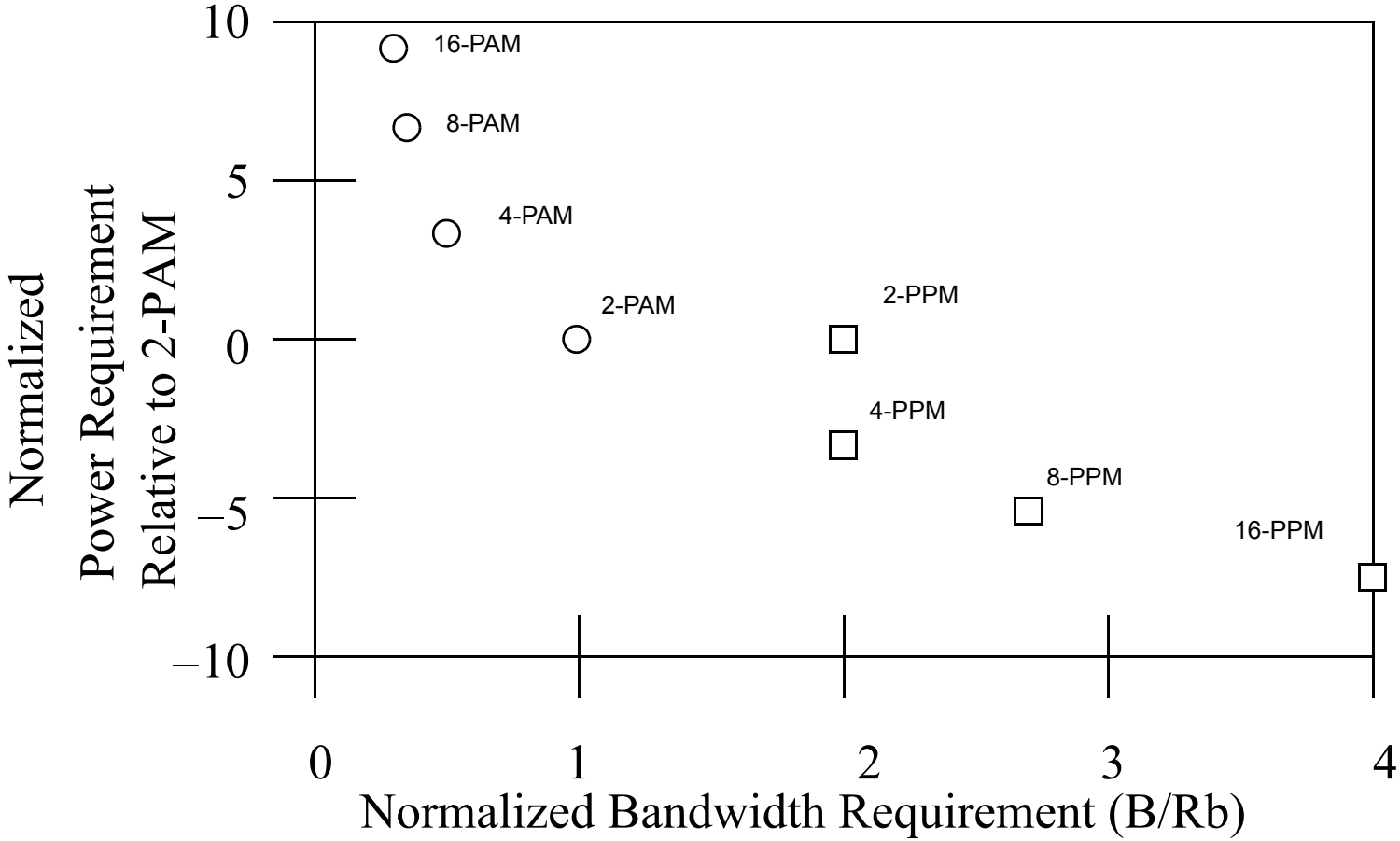
- Choose largest of L samples

Hard-Decoding

- Each sample quantized to 0 or 1 (1.5 dB penalty)

Different Modulation Schemes

- For optical channel (intensity modulation)



IR Systems

Present Systems

- 4Mb/s 4-PPM over LOS systems
- dc rejection to combat fluorescent lighting noise
- Little equalization
- Silicon PIN diode roughly 1 cm^2

Future Trends

- Lower cost laser diodes with diffusers
- PAM modulation for higher data-rates
- 50Mb/s diffuse system demonstrated but not integrated (2-PAM)
- DFE and Max Likelihood Sequence Detectors (MLSD) used to combat intersymbol interference