FSK modulation scheme for IR PHY

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Abstract

In this contribution we make a draft proposal for an InfraRed PHY based on an FSK modulation scheme, with a tilted transceiver to achieve a diffuse transmission required for in building transmission.

Introduction

This contribution is a proposal for the definition of an IR PHY to allow implementation interoperability among different vendors. This submission is for "diffused" infrared. In this specification the term diffused should not be considered such that the transceiver is completely omnidirectional. Truly the proposed system does not rely only on the IR signal bouncing off the ceiling, wall, and other objects to reach it final destination: the photodiodes, as this will restrict too much the cell coverage. The suggested approach consider that some level of aiming is required to cover rooms in which some daylight exist and rooms where latest technology of fluorescent lights are used. It is obvious that when direct path propagation is available the range is greater than when diffused path is required. As an example with the same received optical power the distance will extend from 5 m for a completely diffuse system to 10 m for a tilted transceiver. However it is important to provide some level of diffused path since blocking of direct path may occur in practical application.

Answer to requirements outline

Compliance with regulatory agencies for operation

The IR transceiver under consideration use non-coherent optical communication as it is based on Light Emitting Diodes (LED). The Maximum Exposure Limit for a whole work day is around 1 mW/cm2 as defined by the American National Standards Institute for lasers.

Compliance with 802.11 PAR: Data rate of at least 1 Mbps

In IR communications, modulation takes place in two stages. First the transmitted message modulates a carrier, and then this modulated signal modulates the intensity of the emitted infrared light. The objective of the modulation is to move the data spectrum off the spectrum of the ambient light. The subcarrier frequencies have to be kept above 300 kHz to avoid noise spectrum of ambient light.
Based on the work carried out in IBM Zurich by F.R. Gfeller, in [1], for office environment a sensible choice for modulation scheme is Frequency Shift Keying. FSK is easy to implement, cheap as it can be based on off the shelf mass production components and flexible to speed change.

In addition the carrier frequency can be easily switched to allow several colocated networks to operate concurrently without any reduction in throughput and without user intervention based on a simple Listen Before Talk mechanism at the time the network is brought up.
As one of the main reason for a user to select IR solution is it lower cost the FSK modulation give the capability to use LEDs with longer rise and fall times and with higher "ON" resistance, and Photodiodes with longer rise and fall time and cheaper by a factor of 20. Anyway as the technology evolve higher performance components will become cheaper and therefore this will pave the route to achieve higher speeds.

Minimum area coverage

IEEE project 802, Functional requirements states that a LAN to be capable of supporting segments at least 100 meters in length, this will not be achievable with this IR Technology. However by adding an optical element of few cents this 100 meters distance can be achieved but then aiming is mandatory.

Space loss

- Ps = 1 Watt average optical power per bit symbol
- Ar = 1 cm2 photodiode area
- H = 2 m height of ceiling above desk top (desk height = .8 m)
- ρ = reflection coefficient of ceiling
- R = distance between transmitter and receiver
- with a teta of 15 degree beam with (LED half power angle)

Then the received signal power is approximated by the expression

$$Pr = \rho \, Ps \, Ar \, \frac{H}{(H_2 + (R - H(1 - {}^{-S/H})^2)^{3/2}}$$

For a 4 m distance Pr/Ps = 60 dB which is already very significant and therefore the 100m distance is completely out of range.

Operation in a multinetwork environment (multiple collocated networks)

Thanks to the carrier premodulation scheme several colocated networks can operate together at the expense of several channels being implemented. Given the coverage of an IR system a maximum of 3 to 5 channels can be practically used, and the carrier for those channel can be for example 5 MHz, 7 MHz, 9 MHz.

Suitability for low power consumption implementations

As the receiver noise bandwidth is restricted to the frequency band of FSK and if we assume a channel bandwidth of 2 MHz then the receiver noise will be lower than for other modulation schemes which require a very large bandwidth in the range of 20 MHz, and therefore for the same distance between transmitter and receiver, less transmit power might be required.

Comparison with Manchester implementation

All the data provided hereunder are in comparison to Manchester encoding, when it can provide the function.

1. estimated cost: 1.5

   The implementation of a FM transceiver is more complex due to filtering required to cope with several colocated networks. But for the demodulation process off the shelf high performance ICs are available (NE/SA615) for cellular phones which are fully applicable. to an IR transceiver.

2. Support of multiple data rate: Yes

   Multiple data rate can be based on the capability to use the aggregate channels normally used to isolate cells.

3. Multipath sensitivity: .5

   Given the data rates achievable for a room coverage the multipath to be expected will not exceed 50ns and therefore this should not be a problem. However this transmission mechanism is probably the less susceptible to this problem when compared to the other proposals.

4. Support of multiple co-located channels: Yes As frequency transposition is used the capability to have multiple channel exist.

5. Power consumption: 1

   At the transmitter there will be a requirement for a slightly more power to remain in the linear area of the diodes, but as on the other side due to filtering in the receiver the noise seen by the receiver will be lower the overall consumption for a given distance between transmitter and receiver will level the power consumption figure for both FSK and Manchester.

6. Stress on LED: .75

   As the diode are used in their linear zone they are much less stressed than in any other proposed encoding scheme.

7. Preamble length: 1.25

   Timing acquisition can be made within 24 bits.

8. Signal to Noise Ratio:1

   The error rate performance will not be significantly different between Manchester encoding and FSK modulation.

BIBLIOGRAPHY

[1] F.R. Gfeller, *Infranet: infrared microbroadcasting network for in-house data communication*, ECOC 81, Copenhagen, Denmark, pp.27-1 to 27-4. Sept. 1981.