Tentative IR-PHY Adhoc Group Meeting
Wednesday, May 12, 1993

The meeting was called to order by Tom Baumgartner 6:15 PM. Carolyn Heide secretary. Agenda is document IEEE P802.11-93/52 . Tom apologizes for the re-schedule of the meeting from Monday to Wednesday.

1. Adoption of Agenda - by consensus

2. Presentation of information on IR emitter and detector suppliers and their products

This paper deals with emitters only, not detectors. Will try for detectors next time.

Infrared Sources for Diffuse Communications Links, IEEE P802.11-93/55,
by Jeff Welch, presented by Tom Baumgartner

Question - aren't laser diodes narrow beam? Yes, but you could diffuse them with optics.

Chart on page 4: Siemens parts are not production parts but samples running in the lab. They plan to bring out one single part that runs between the specs of these two. The Stanley part has been in production for quite a while. Don't know much about the Hamamatsu and Hitachi.

How is efficiency measured: power in measured by volt X amps and radiated power out in nanowatts per square centimeter - not sure what units used.

Lou Dadok (who is present) is a product manger for HP.

Speed eliminates a lot of suppliers - nothing less than 100 nanoseconds is on this list on page 4.

IR technology is in a state of change. People are investing money in LED technology - page 5 lists things that are changing.

How is switching time related to response time? The same really - it is equal to rise or fall time.

Francisco Jose Lopez Hernandez: eye damage comes from the front of the laser, whole light path is covered, that can be changed. Spatial coherence is what makes lasers dangerous. Diffuse with lens keeps short switching time, but removes danger. CD player laser is about $5 and can be modulated about 2 GHz. Fast LED has about same price, so price is not an issue.
Tom: thinks we should watch the laser diode area, but user LED diodes.
Rui Valadas: power emitted is about the same as LEDs, so you need multiple, and all the driving circuitry. You have to temperature and power control, so the driving circuitry can be more complex. They are faster though.

DC efficiency versus pulse efficiency? Run a DC current and look at the power output. As you increase current the efficiency falls. But you have to start to pulse to keep from overheating the diode. So the DC current efficiency is low current efficiency and the pulse efficiency is high power efficiency.

Larry van der Jagt: the laser diode is $5 and you have to package it and add the optics to diffuse it. The equivalent LED is $.50 . Volume would make the price lower but packaging drives it up.
Rifaat Dayem: but they are so much faster.
Francisco: must diffuse them and then concentrate them - could only be a bit of plastic.
Larry: faster part, lower output power, or slower with more power.
Tom: as fast as the laser diodes are we would probably choose to slow them down and give us more power.

Wavelength farther away from visible light makes easier interference elimination. Narrow spectrum makes for easier filtering.

Rifaat: do LEDs come in 2 flavors only?
Tom: Most popular are 830 nm range plus or minus. There are 960 but they're not fast enough. There may be others too.
Francisco: Hitachi has 4 parts with 4 different wavelengths in the IR window.
Paul Fulton: 840 to 880 nm for fast parts. 940 is in remote controls, slow rise time. Fiber uses 1100 -1300.
Tom: if the fiber optic components came available that would be great.
Paul: power and launch window problems.
Tom: Sarnoff Research discussed that they can array LEDs on a single substrate that might be applicable. Connection in parallel is coming sometime.

Rifaat: narrow spectral bandwidth?
Tom: if parts put all energy in a narrow bandwidth stable with temperature, that provides ability to use thin film filters on the receivers.
Francisco: angle of incidence makes lensing more of a challenge.
Rifaat: rise time determines out how much data can be pushed through, it's not related to spectral bandwidth?
Tom: we are not using a diode like an RF transmitter and modulating that diode like an RF carrier and imposing a data signal on top of that. Usually just OOK, so rise and fall time determine speed. Spectral output is just light frequency. It is an advantage to have that as narrow as possible.
Larry: same problem with chromatic dispersion as in glass.
Richard Ely: in a room you don't have point scatterers, it comes back
Larry: chromatic dispersion in distance traveled is a small effect compared to switch time.
Francisco: differentiate point to point diffuse from purely diffuse. Dispersion is important in diffusion, but from multipath not chromatic.
Rifaat: why don't you modulate an LED?
Tom: it's not that it can't be done, but believes it's not worth it economically yet.
Paul: wireless headphones do it. Around 100 Kh to 2 MHz, probably FM .
Larry: you would have to build AGC if AM.
Rui: baseband is better for BER performance for suitable complexity of modulation scheme.
Tom: power is an overriding consideration and OOK is more conservative.
Richard: v-cell lasers are nice because a lot on one chip, but they are inefficient due to high resistance so not a good candidate for the future either.

Paul: these are things nice to do - which are most important.?
Rui: power efficiency.
Tom: yes, once you have gotten to a good speed. Also good surface mount packaging

Rui: requirement to have at least LEDs with 2 different beam widths. One wider and one sharper to optimize the emitting pattern of the emitters.
Tom: component like Seimens do supply in multiple beam widths. Their surface mount package is 120 degrees, so a bunch on a flat surface gives good coverage.

3. Discussion on methods of conformance testing of IR transmitters

Paper from Spectrix planned this for this meeting, but not ready, will try for next time.

4. Discussion of any "strawman" specifications of the IR-PHY that are brought forward

No submissions for this.

Rifaat suggested looking at an old spec from Dick Allen. Tom responds yes - a little review of that was done last time. A good start would be to start from there.

5. Any other topics of interest

First paper relates to the channel, the second to the transceiver.

Propagation Losses and Impulse Response of the Indoor Optical Channel: A Simulation Package, IEEE P802.11-93/78, by Rui Valadas

Channel components: the emitter (LED), the room, the detector (pin photodiode).

Characteristics correspond to commercially available LEDs (such as Stanley or Hitachi). Uses wider and sharper LEDs in combination. Sharper to illuminate farther spots in room and wider for straight down. LEDs with more suitable characteristics would have given less loss.

First case described.

Tom: less dynamic range might help in receiver design?
Rui: yes. Also this model assumes the room is empty. This is a good assumption in the case of propagation loss. Furniture will increase dynamic range but help propagation loss. So these numbers are worst case probably.
David: explain mechanism of losses in the room - just propagation losses in this case? Free space losses from the satellite to the receiver plane are not considered? (square of the distance law and the characteristics of each LED). What is the difference between the shortest path and the longest for this model?
Rui: 3 meters straight down, circle cell radius of 6 meters.
David: difference in distance is only a few meters, so why 14 db difference between directly underneath and at the edge?
Rui: accounted for beam angle as well as distance. Scan receiver through circular area - when in center it gets a lot of power because LEDs all pointed to floor. Must consider the radiation pattern, the characteristics of emitting pattern, as well as distance. Also the receiver is oriented vertically, so losses for active area of receiver.
Francisco: units of losses - db per square cm?
Rui: propagation losses computed by 1 square cm of active area.
Francisco: double area receiver gets double losses.
Rui: difference units at emitter and receiver.

Second case described.

David: if reflection coefficient of the ceiling is 1, get same results as case first.
Rui: difference - the satellite defines the center of the cell, so the worst case difference is satellite to the boundary. Here satellite and receiver are on the same plane, so they can get farther apart. The two cases cannot be compared like that. The satellite comes from one spot on ceiling, but emitter with big range has wider dispersion.
Tom: .8 coefficient of reflection from ceiling is realistic?
Francisco: yes. About .85 - .9 measured on white ceiling.
Rifaat: has seen results that say .7 even from the worst ceiling.
Rifaat: multiple reflections or just direct path?
Rui: because 1 Mb/sec we know reflections are not a problem. No, energy from multiple reflections not considered. Reason - figure for designing a system and these should be worst case figures, so don't account for things that vary from environment to environment. No side walls assumed, no reflection to help.
Richard: reflection coefficient measured in IR?
Rui: Yes. Radiation pattern of ceiling is also important, Have been assuming pure Lambertian. In other cases we will have to use a satellite for sure.

Modulation/Encoding Techniques for Wireless Infrared Transmission, IEEE P802.11-93/79, by Rui Valadas

Francois: did you consider FSK?

Rui: not here, but in a previous work compared modulation and baseband. This is only about baseband.
Francois: worried about multiple channels required to support network overlap.

Manchester

Rifaat: partial response is a filter?
Larry: it is a modulation, it is a filter.
Rui: works so well because the partial response filter has a shape which corresponds to a sine, which cuts a lot of the noise power which is produces by the AC current.
Larry: since Manchester encoded data has no DC component, you could high pass filter the signal and there would be no DC.
Rui: it is not DC, it is low frequency component of the signal. A good approximation of this filter is just a first order high pass filter and a first order low pass filter.
Larry: agrees. But look at Manchester as BSK with binary frequency = data frequency. If you put in an interference filter the system will work better. Match the filter to the signal.

PPM

Rifaat: you need faster rise time diodes for high levels of PPM?
Rui: yes but not drastically. A pulse width half of the full width of Manchester.
Rifaat: data rate still totally limited by the rise time of the LEDs?
Rui: of course.
David: so if you don't do this you can go higher than 1 Mb. If you can deal with 16 phase for 4 bits, then you can use higher than 1 Mb with Manchester.
Rifaat: but you don't get the power saving - trading speed for power.
Rui: the relative gain remains more or less the same as the data rate increases. Because somewhat narrow pulse in PPM, problems with multipath will arise sooner with bit rate increase. Manchester is also easier to implement, so that should be considered.
Rifaat: different path lengths of 250 nsec for large building.
Tom: 1 nsec per foot, typical path of 50 feet, so we talk of 50 nsec different path lengths.
Carolyn: room size is important not building size.
Rifaat: maybe the 250 number is for radio.
Larry: why Manchester not NRZ?
Rui: 2 problems. (1) cannot assure minimum number of transitions, so expensive clock extraction - a soft filter or something.
Tom: and staying above optical noise in the bandwidth.
Rui: that is better in NRZ than Manchester. (2) DC wandering - not enough pulses will allow wandering.
Larry: packet length, difference clock, cheap synthesizer circuits, minimum transitions before locking. A twice synthesizer is not very expensive. You are using twice the bandwidth to go Manchester to get these advantages. Twice the bandwidth allows twice the noise too.
Rui: but this compares Manchester and PPM - in terms of sensitivity PPM is better than Manchester and NRZ.
Frédéric: but what is the weakness of PPM?
Rui: complexity of implementation.
Larry: noise immunity.
Rui: what noise did I miss in this simulation?
Francisco: noise is similar to interference signal. About 3 orders of magnitude above the shot noise.
Rui: not accounting for things you can filter out.
Larry: at 120 Hz and higher there are significant interferers. A BPSK signal (Manchester with carrier freq = signal freq) could move entire spectrum away from the lights and totally filter out the impact by moving a little higher. Agrees Manchester better than NRZ if noise sources are all close to DC.
Rui: extent of interference are harmonics such that you can filter them out without signal degradation.
Francisco: the new electronic ballasts are switching about 100 KHz.
Larry: but you are throwing away db's of sensitivity.

David: signal almost not affected by that. You have to move away from 100 KHz if the interfence is there.
Tom: cost trade off.
Rui and Larry discuss Manchester for quite a while.

Paul: what is the spectrum of florescence?
Francisco: far from IR, mainly in green and blue. Part that is near red is very small.
Rifaat: what about incandescent and outdoors?
Tom: outdoors the DC component in the photodiode goes up, so range is reduced. Practical inside incandescent are a lot less.

Data Encoding Schemes for Infrared Signaling, IEEE P802.11-93/57,
by Ellen Oschmann, presented by Tom Baumgartner

More of a discourse on the possibilities than an analysis.

Data rates in the 4 Mb range considered.

The third Paragraph on page 2 - Larry applauds, Francisco disagrees.

Francisco: nobody expects that power between photodiode and amp is coupled. The output voltage increases linearly with optical power. Independent of input impedance of amp.
Larry: output voltage is what you deal with in detector decision. So you don't have the square law thing. Decision based on output voltage, so you don't get this proposed advantage.
Francisco: but the noise - a higher pulse with of narrow duration. Same energy in shorter pulses.
David: what is the spectrum of the noise from the output of the amp?
Larry: i over f?
Rui: shot noise is white noise. the shaping filter of the receiver and help.
David: shorter noise, wider filter.
Francisco: not so much more. Volt noise is the square root of that. So there is an advantage.
David: limiting noise, SNR is improved with shorter pulses with higher power.
Rui: the energy per bit is higher for Manchester. Because voltage goes up linearly with power.
Tom: the author only considered voltage component, didn't consider component of noise going up.
David: for the same level of noise if you increase power twice you increase SNR by 2.

Author looks at the reality of parts on the transmit side. There are limits on how far the emitter power can be pushed. You can add more LEDs.

Manchester with consideration of partial response filter also, might change what the author said here.

PPM - author predisposed against it because LED propensity to have unequal rise and fall time introduces bias.

RZ - this is the author's choice.

Paul: why is RZ better at higher rates?
Tom: for the 4 phase PPM 4 bits become 16 slots and you now have to find the pulse in one quarter bit time. At higher rates the multipath becomes a higher % of a bit time. As you approach 10 Mb that will become a factor. Rui, have you ever considered RZ?
Rui: the spectrum of receive has a large lower frequency component. In view of interference that becomes significant.
Tom: that's why the author proposes the large amount of bitstuffing.
Rui: not sure that bit stuffing reduces the low frequency. The balance between the 1 and 0 is what causes the DC. By doing bitstuff we don't necessarily bound the digit sum variation.

6. Preparation of submission to MAC group regarding how the MAC can affect the IR-PHY

Making sure MAC hooks for IR PHY are there - encourages someone to bring this submission.

7. Plans for future actions and meetings

Larry thinks the full PHY group would rather not deal with IR. So continue this forum for IR.

Does anyone expect anyone but Rui and Tom will have papers? Francisco is planning to bring works that have been done. Also wants to experiment on lasers diffusion to remove health risks.

Spectrix will bring conformance testing submission and pin photodiode survey equivalent to LED survey this time.

Would be good if someone would bring a strawman proposal.

Larry - do you thinks if you had to decide on a modulation scheme now you could? Tom thinks if we did decide now it would be Manchester. That is where there is the most common ground. Rui thinks there are significant db advantage for PPM, a well known result from fiber optics. Tom thinks that the multipath problems would have to be studied a lot more.

Richard: if we selected something, we would have made some progress - we would have something to shot at, and it helps management to decide to commit time.
François: Manchester has the low frequency noise problem.
Tom: in the radio area as soon as someone put out a proposal it stimulated submissions to shot at. But if we put out a proposal we are compressing a year and half radio work into 2 meetings.
Larry: get the other vendors in here.
Rui: I don't know what things need to be in a standard for an IR PHY.
Larry: pull a fiber optics spec and look at it. 802.4 for instance. It is in ISO 8802.4 books, not in the yellow books.
Francisco: if laser diodes can be used the possibilities broaden. Can go to 100 MHz FSK.
Tom: should not rule out the wide possibilities. For the first spec we need to not take a long time because of considering everything possible. 1, 2 or 4 MB is plenty for the first spec. Low power and cost are the driving criteria.

Next session is a plenary, so Monday morning is good for the next meeting. Any and all papers are invited. Invite everyone you know that might be interested.

Meeting adjourned: 9 PM