IEEE 802.11
Wireless Access Methods and Physical Layer Specifications

Minutes of the IR PHY Ad-Hoc Group

July 12-14, 1994
Orlando, Florida

Tuesday AM, 7/12/94, IR PHY

The meeting was called to order by Roger Samdahl at 9:00 AM on Tuesday, 7/12/94. In attendance were: Robert Buaas, Kimillo Feher, Chuck Brown, Hirohisa Wakai, Manual Betancor, Werner Just, Rui Valadas, Peter Blomeyer, Francisco Lopez-Hernandez, Del Hanson, and Barry Dobyns joined in.

Since there were no volunteers for acting Secretary, Samdahl asked if anyone would object to having the proceedings tape recorded for later transcription. There were no objections.

> *[Samdahl has transcribed these notes after the meeting week was completed. As editor, he apologizes for the many mistakes that have certainly crept in and for the length of the document. This was a heated meeting and at several points it was stated that comments were being made for the purpose of getting the comments into the minutes of the meeting; the editor has done his best to accomplish this, recording the comments verbatim, where possible. Unfortunately, the taped statements were unintelligible in a few places, and a few words were impossible to recover. In these cases, the editor has used ellipsis to indicate the missing word(s).]*

Samdahl reviewed the objectives for the week's meeting:

- Decide values for PHY frame size and MPDU size
- Edit draft PHY standards for baseband and carrier based PHY's
- Define Clear Channel Assessment method
- Resolve PHY Layer Convergence Protocol Issue
- Resolve PHY Layer Control Headers
- Respond to questions from MAC group

Roll call was taken and a participants list was circulated.

The voting rules were discussed. Only full IEEE 802 members can vote and Samdahl suggested that a 50% rule be used rather than the 75% rule used previously, based on discussions with Larry Van Der Jagd regarding Vic Hayes' intentions. Motion that we use a 50% rule to pass technical issues on to the Plenary, 7,0,0. (Motion by Buaas, Second by Feher).

Minutes were accepted by motion 7,0,0 (Feher, Buaas), with a comment from Feher that there was an error in the description of the power requirements for a carrier based system. Feher agreed to accept the minutes subject with the provision that he would comment later on the error and provide correct information.

No new matters arose from the minutes.

The schedule for the next 3 days was reviewed by Samdahl.

The editors of the baseband PHY were asked by Samdahl to report on progress toward drafting a working standard. Note that Rui Valadas was present as one of the editors and Barry Dobyns, the other editor, was absent.

Rui reported that he was following the format of the FH draft specification. He indicated that the PHY SAP portion of the FH and DS specification was being removed and that the same would happen to the section (2) in his current draft. Samdahl indicated that the draft standard would be delivered later in the day. Feher said that the draft standards (both baseband and modulated) must receive the most rigorous of examinations. Samdahl reviewed the process of developing the draft standard at the sub-committee level: the editors are responsible for incorporating language reflecting the decisions of the subcommittee into the working draft of the document. They do not add 'content' to the document. Their output is accepted at the next meeting through a normal motion. Only then should further changes be offered for the standard.

Feher indicated that an updated version of the Modulated Carrier IR PHY Template would be introduced as a submission later in the day. He indicated that this document would contain only corrected or updated information approved at previous meetings.

The submissions list for the week was reviewed.

Samdahl raised the issue of the requirement put on the IR PHY Sub-Committee to review the recommendation for FQPSK and to come back with a justification for the use of a patented technology. Feher voiced several concerns relating to the way FQPSK had been supported during the Plenary review both in Oshawa and in Orlando. His concerns included statements by Samdahl before the full Plenary of 802.11 that insufficient study had not been devoted to discussion of competing modulating techniques within the IR Sub-Committee during the Plenary sessions on 7/11/94 and statements by Dobyns during the closing Plenary session in Oshawa suggesting that large amounts of battery power would be required to operate a carrier based IR LAN system. Feher went on to describe the large amount of work that had been read into the proceedings of the IEEE 802.11 Working Group and Sub-Committees by supporters of FQPSK, all indicating that FQPSK is superior to any competing modulation techniques in applications requiring non-linear amplification. Feher also requested that he be allowed to resubmit previously presented papers supporting FQPSK. He stated that doing this, and coming back to the Plenary later in the week with a 'join view' would help him and his legal group to postpone any procedural requests to IEEE headquarters. Feher went on to point out that all of the other contending modulation techniques had been rejected by the IR Sub-Committee. He indicated that he hoped that the Sub-Committee could get back to the PHY and MAC/PHY groups with a strong uniform vote and avoid a situation in which he and his corporate partners would have to uses the appeals procedures available through the IEEE. Feher also raised the question of

whether the PHY Committee had approved of the FQPSK modulation motion later presented to the full Plenary in Oshawa. This was affirmed by Samdahl and several attendees.

Samdahl responded by noting that his comments had been prefaced by the statement that he was speaking as a attendee of the IR Sub-Committee and not as its chairman, and that all of his statements to the Plenary acting as chairman of the IR Sub-Committee had been made using language taken verbatim from the motions that have been passed by the IR Sub-Committee for approval by the Plenary. Also, that in light of the intellectual property lecture that was given during the Plenary, Samdahl could not state that adequate evaluations had been made within the IR Sub-Group of the competing, non-proprietary, technologies most similar to FQPSK. Samdahl also indicated that he was in no way responsible for statements made by other IEEE members regarding their opinions about any particular technical issue.

Samdahl went on to state that he felt that a repeat vote by the same people on the same issues would have little effect on the decision of the full Plenary toward the matter of FQPSK. Feher agreed. Feher asked if he could represent 94/65 which was presented previously in Oshawa and which contains comparison charts for various forms of modulation techniques and which also contains an extensive bibliography of supporting papers. He indicated that the paper shows that FQPSK is about 12 dB than competitors.

There followed a general description of the IP statement process and its application to the specific issue of FQPSK.

The chair asked Feher what the next best competitor for FQPSK was. His response was FSK, and later GFSK. He indicated that QPSK and OQPSK were inadequate in regimes with non-linear amplification.

The chair suggested that the group ask for expert support from outside of the Sub-Committee to help resolve this issue. There was no support for this suggestion and it was dropped. Feher's comment was that the past voting patterns of 802.11 members outside of the IR Sub-Committee would most likely lead to an appeal procedure. This subject continued to be discussed for a substantial period. Feher suggested that the chair had a conflict of interest.

Blomeyer indicated that papers that FQPSK was well documented and defined, contradicting a statement made by Larry Van Der Jagd that 'FQPSK' was meaningless and undefined.

The point was made and emphasized that no competing technologies were brought forward and supported during the closing interval of evaluation of modulation standards for IR.

The chair indicated that the papers would be taken in order, but preceded by a reprise or 94/65.

Feher presented the reprise of his paper 94/65.

Feher also reviewed 94/51.

Feher pointed out that the Japanese are now promoting systems very similar to EXIRLAN. Multi-carrier approach limited to 30 MHz.

Feher referred to a paper by Kahn, at UC Berkeley, which he believes reports that modulated carrier systems are more optically efficient than any of PPM systems. Power efficiency is the most important characteristic of IR systems, spectral efficiency second.

Larry VDJ asked how the waveforms for FQPSK, and offset QPSK in general, are actually generated. Chuck Brown responded with a short tutorial. Comments and questions centered around the differences between FQPSK (Feher QPSK) and other forms of filtered offset QPSK. Feher pointed out at one point that the standard will not specify implementation details but should specify the waveforms. Feher indicated that the information he was giving now had been given to the IEEE many times in the past. Feher explained why these waveshapes are so much better than GMSK or MSK. MSK produces a discontinuity in the baseband waveform.

Feher reiterated that his patented FQPSK is at least 5 times better than the nearest competitor.

There still seems to be uncertainty about what the patented technology incorporates. Point was made by Feher that SQAM is another patented technology that belongs to his group. Feher believes that all baseband waveforms that are spectrally as efficient as FQPSK are covered by one or more patents (his plus others).

Larry VDJ suggested that a better approach would be to specify a modulation similar to FQPSK that did not infringe on the FQPSK patent, but which could intemperate with an FQPSK system. That way we could get around the intellectual property objections posed by the Plenary. People could then use the patented technology to get a technical advantage over those choosing not to use it, but it would not be mandatory. Feher pointed out that anyone coming up with a competing technique that meets the requirements of the template and IR PHY draft standard (yet to be written), would be free to use that approach.

VDJ suggested that the standard, when written will specify measurable quantities, such as waveforms and frequency masks and that these could have enough latitude to permit non-FQPSK types of filtered offset QPSK. Brown pointed out that a looser waveform mask would result in poorer spectral efficiency and would impact the assignments of operating frequencies.

Feher agreed in general to VDJ's suggestions, stating that the FQPSK could be replaced by 'filtered offset QPSK'. Then Feher stated that there was nothing within 10 dB of being as spectrally efficient as F(eher)QPSK and then showed a slide from paper 94/51 (figure 5) which shows the power efficiency of FQPSK to be 8 dB better than GFSK at 10^-5 BER. Feher indicated that GFSK is the closest competitor to FQPSK when power efficiency is the critical parameter.

Samdahl asked if Feher or others planned to explain how the filtered baseband FQPSK signal is actually impressed on the IR. Feher indicated that it was discussed in paper 94/55 in March `94.

There followed a lengthy discussion of spectral regrowth characteristics of several modulation patterns under conditions of non-linear amplification, with opinions being voiced that this was a strong advantage of FQPSK. LVDJ again suggested that we should define a waveform mask that was close to the FQPSK model but that allowed room for non-proprietary techniques, as well as FQPSK. Feher agreed and said he would draft a paper for delivery later in the day that would recommend changing from FQPSK to filtered, offset QPSK. The discussion moved to how the draft standard should be worded; Feher and Brown commented that it should include time-domain masks for the modulation as well as spectral masks for the modulated carrier. Feher suggested that the draft should require filtered, offset QPSK conforming to the specifications set out in document 94/131r1 (the modulated carrier template). Valadas suggested that the 94/131r1 template would have to be modified to allow more band separation if the spectral regrowth specifications were relaxed. Feher said that this is not true. This discussion continued with LVDJ again suggesting a relaxed standard to allow non-proprietary solutions and Feher responding that the current template or 'standard' was written around 20 dB points for band separations, as with other PHY's, and that that needed to stay in the draft.

Samdahl recommended that the agenda for the afternoon should start with the formal presentation of registered papers and that the end of the afternoon be set aside to allow for preparation of new presentations to be given tomorrow.

Tuesday PM, 7/12/94, IR PHY

Wordsmithing continued on the new language to be used to describe the carrier modulation technique, without any final conclusions.

Submission 94/146, "Low Power Implementation of FQPSK Chip for Infrared and Other Wireless Implementations" was presented by Chuck Brown. This paper described an FQPSK implementation of an FQPSK transmitter. Questions for Brown were limited to issues of cost versus quantity. He indicated that the FPGA solution suitable for small production runs and that the designs can migrate to a fixed cell version for larger production runs.

Before we got started with the next presentation, Lopez-Hernandez brought up an issue of the units used for radiant power incident on a detector. We commonly use the units of dBm/cm^2, but he points out that using a logarithmic term is confusing because we have to think simultaneously of the additive properties of logarithmic units and the multiplicative units we usually use to take about active area changes in the detector. Betancor agreed to prepare a presentation to address the problem.

Submission 94/152, "Physical Layer Draft Specification for Baseband Infrared Media" by Rui Valadas was next. The draft is complete except that the current section two, the Physical Layer Service Access Point (SAP) will have to be deleted to conform to a change made in the PHY specifications for all PHY's by the MAC/PHY Interface ad-hoc group. This section will be

moved to a common section that applies to all 802.11 PHY's. Samdahl made the point that someone must take responsible for incorporating the common version of our section two into a common section in 802.11 draft standard. Rui pointed out that this document does not contain anything that has not been approved in earlier instances of this ad-hoc meeting; he and Dobyns have acted only as an editors in preparing this draft. Feher pointed out that we may have to move drawings to an appendix and convert them into text in the body of the spec. Valadas responded that other standards have included drawings. On the technical side, Feher pointed out that an included bandwidth specification of 0 to 5 Mhz was meaningless unless the attenuation levels are specified. Valadas responded that he was only incorporating the actual text of passed motions.

In the midst of this presentation the question of open issues came up. Samdahl reminded the group that the PHY groups, in general, had only one open issue, that is "what is the ??? PHY".

Back to the presentation, Feher suggested that we needed a transmit signal mask; Valadas pointed out that there was a section for such a mask, but it was a TBD.

Samdahl pointed out that the process we're involved in is one of reviewing a draft of a specific PHY document as edited by our selected editors, Valadas and Dobyns. We must review the draft, approve it and then work on changes. Feher then moved that the 94/152 draft document be accepted by the ad-hoc group as the draft standard for the baseband IR PHY. Buaas seconded. Motions passed: 8, 0, 0.

Valadas then presented presentation 94/153 "Proposed Revision to the Proposed IR Frame Format". This is a recommended change to the just adopted Draft Specification. The recommendation is intended to modify the Start Frame Delimiter and End Frame Delimiter and to replace them with a CRC protected length field in the PLCP. Hamming distance was one problem with the original version, but equally important is the political advantage of using a format common to the other PHY's. Buass commented on the confusion caused by the use of 'slots' to describe part of the preamble or header and 'bits' to define other parts. Valadas explained that the use of 'bits' was for clarity to persons outside of the IR ad-hoc group and that 'slots' was the only mechanism available to explain the character of the preamble which consists of illegal 16 or 4 PPM patterns. Buaas pointed out that even if we make this change, we have an obligation to demonstrate that we have a Hamming distance of 4. Feher recommended that we add a specification for Eb/No. Valadas responded that the method he used was the one that is conventional for baseband systems. Valadas moved that we accept this modification to the draft standard as proposed by the IR PHY ad-hoc group, Buaas seconded. Motion passed 8, 0, 0.

Feher indicated that he wanted to introduce 94/131r1 before we break for the day; Samdahl agreed.

Valadas presented 94/154, "Band limitations.....". Basically, he indicates that the power spectral density of the 16 and 4 PPM will impinge on the 'coexistence' band as previously agreed to. His conclusion is that we should abandon the possibility of coexistence in favor of an assumption of spatial reuse. That is, that one form of IR PHY will be bounded by physical walls and will therefore not interfere with other IR PHY techniques used in adjacent physical areas. Feher

commented critically on the poor spectral efficiency of the proposed 4 PPM. There followed a vigorous conversation on the expectations for use of the coexistence band. Some members indicated that the coexistence band was reserved for 'first come, first served' traffic. Others commented that this was not the definition that had been used during the May meeting to define this band. All agreed that the 'coexistence band' use was not defined clearly. Lopez-Hernandez pointed out that the bandwidth used by the baseband was excessively wide as measured by bits per Hz of used bandwidth. Valadas asked whether carrier systems expected to use the coexistence band. Feher respond.. 'yes'. Samdahl reminded the group that our agreement to define two PHY standards was dependent on the non-interference of the two standards, a motion which had been passed by the full Plenary 802.11. No motions were offered.

Feher reminded the group that there was much fine-tuning require to define the co-existence band. He suggested that the issue be tabled until later.

Feher presented 94/131r1, "Template for Carrier Based IR PHY???". The document was presented as an edited version of the original, incorporating changes adopted at the May meeting. Issues were raised about a few changes that appeared relative to the original version of 94/131 that were not approved by the ad-hoc IR group. These included reference to the levels of attenuation expected at the boundaries of the coexistence band, the inclusion of Eb/No specifications. Feher pointed out that the Eb/No spec was included in the template adopted at the May meeting. Samdahl apologized. Discussion continued, focusing on details not present in the draft template adopted at the May meeting. As a result we removed implied usage of the coexistence band and the resulting use of that band to provide some of the channels assumed by the modulate carrier forces. Samdahl suggested that the Template document needs to be converted into a draft specification. Feher disagreed, indicating that this was the only form that had be approved by this group. Samdahl pointed out that there was a difference between a template (or specification) but agreed that the template represented the essence or the agreements that have been reached relative to modulate IR. The presentation continued, and again, the use of the coexistence band was rejected, at least as far as any specific reference in the template for the modulated carrier IR PHY template. The group also requested that any reference to the two PHY standards be removed from the modulated carrier IR PHY proposal. This is consistent with the way the standard has been written for the baseband IR PHY. On request, Feher described how to calculate Eb/No as he defines it, as a measure or performance for modulate or baseband systems. Feher explained the method. (See attachment).

Feher suggest that Eb/No is the proper measure to be applied as a conformance test. In any case, there appeared no reason to change the modulated carrier PHY template to avoid this language.

Samdahl asked that the document be corrected as agreed to by the group before any vote of acceptance is taken. In any case, Feher agreed to modify the template to prohibit interference with the coexistence band.

There followed a complex argument regarding use of the coexistence band. Although there was give and take regarding use of the defined co-existence band, no conclusions were reached.

Feher agreed to modify his presented document to avoid statements regarding the coexistence band or any reference to the dual PHY's defined for IR.

There were somewhat veiled comments indicating that there would be a critique of the spectral efficiency of PPM systems in later presentations.

Buaas moved that the modified document represented by 94/131r1 be accepted as the working template for the modulated carrier based IR PHY. Feher seconded. Discussion was heated, but the final vote unanimous, 9, 0, 0 to accept 94/131r1 as the updated template document for a carrier modulated IR PHY.

Meeting was adjourned.

Wednesday AM, 7/14/94, IR PHY

Meeting was called to order by Samdahl.

Valadas revisited the issue of coexistence, again emphasizing the importance of spatial reuse of the available spectrum as opposed to frequency reuse. Valadas reviewed the reasons for the two distinct IR PHY specifications. He made the important point that no matter what the IEEE 802.11 does, there will be competing technologies in the market at the same time we are, if not earlier. Valadas pointed out that the radio PHY's for FH and DS have a similar problem of coexistence, one that is perhaps even more serious than that associated with the two IR PHY's. IR has the advantage of spatial containment that radio lacks. He also made the point that future baseband systems, IEEE compliant of not, will appear at higher bit rates, up to 10 Mbps, and will use the current coexistence band of necessity. He concluded that both IR PHY's should be able to use the whole DC to 30 Mhz band.

Samdahl indicated concurrence with Valadas, but voiced the hope that the two PHY's can still be defined in a way that allows them to defer to each other in a reasonable fashion, but that it is getting somewhat late to do this with the deadline of November for the draft standard.

Blomeyer voiced his disagreement, pointing out that the IR ad-hoc committees goal should be to clean up the bandwidth allocation 'mess'. He voiced strong disagreement with allowing the mistake that the two radio PHY's have made to be an excuse for repeating the mistake with IR. He went on to make the point that baseband ought to be constrained to the band from DC to 5 Mhz. Francisco agreed, pointing out that it is the baseband signal that is exceeding its allowed band.

Samdahl asked that this discussion be tabled in favor of returning to the planned agenda. Feher agreed, pointing out that some attendees had obligations that would require them to leave at the end of the mornings business. Buaas agreed, pointing out that the current conversation was 'new' business and out to be deferred in favor of cleaning up 'old' business.

Lopez-Herandez presented paper 94/_____, comparing the overall performance of baseband versus FQPSK systems.

Feher stated that the comparisons presented in this paper were supported by experts at AT&T, IBM and Berkeley.

Valadas was very critical of the presentation because supporting math was not provided. He pointed out that the displayed data indicates that 10 Mbps takes the same power as a 4 Mbps system and asked why even bother with 4 Mbps if this is the case. Feher pointed out that in terms of Eb/No, all systems sharing a common modulation system will have the same required energy per bit for a given Eb/No.

The discussion shifted to the question of whether linear diodes would ever be available and if so, what would they cost. W. Just suggested that they are a long way away and that, in any case, more linear diodes would certainly be more expensive. He recommended that for practical devices in today's market we should assume that we need to stick with the non-linear characteristics normally associated with conventional diodes.

Valadas stated that the data presented in Lopez-Hernandez's paper contradicts several previous submissions and indicated that there must be some mistake in the presented analysis. He questioned whether operating range was taken into account. Lopez-Hernandez said that it was.

Samdahl cut off the discussion and moved to the next presentation.

Brown and Buaas presented a new submission, 94/1XX, regarding a defense of FQPSK. Emphasis was on the non-linear nature of LED transmissions, and the spectral efficiency of FQPSK. LVDJ suggested removing BER from the presentation. It should happen at another point in the specification, where the packet to be delivered to the MAC is defined. Buaas disagreed, indicating that BER is modulation method specific. Larry suggested further that we should include a channel interference profile, and that a set of transmit masks, channel and interference profiles would be sufficient.

Discussion following the presentation were directed initially at ways that the presentation could be made to the Plenary in politically acceptable way. Initially, comments suggested that the role of intellectual property was to be suppressed in favor of a more general specification that might allow for non-IP techniques to apply. But as the discussion progressed, it was clear that the sense of the group was that F(eher)QPSK was, in fact, what the IR PHY wanted to have moved into the standard, not a watered down version. It was pointed out that this is consistent with motions passed in this group in March and May. The group found it impossible to allow an option for the standard that would allow non-IP implementations, even with FQPSK being recognized as a superior implementation within the spec.

As the discussion progressed it became clear that the sense of the group was that the patented technology was, in fact, required to meet the specified objectives. This conversation was very intense, and moved fore and back as the group attempted to find language that would both satisfy

the consensus of the ad-hoc group and have a chance of getting adopted in the Plenary. Ultimately, this seemed to be impossible. The ad-hoc group believes that the properties of F(eher)QPSK are sufficiently superior to those of available competitors that we are in fact intending to write a specification that requires the patented technology. Final agreed statements indicated that the IR ad-hoc group had not changed its position from that held on Monday when the motion was made to the Plenary. Feher strongly made the case for not changing the groups recommendation, and the group agreed by consensus.

Feher expressed the opinion that the issue in the plenary was a politically motivated rejection of patented technology, and was not based on technical qualities. Buaas disagreed, indicating that that was not the language that had been used by the maker of the motion in the Plenary (Paul Eastman).

Feher requested that the following statement be read into the minutes. (The editor apologizes for any unintentional errors in transcribing a noisy tape.) "There were suggestions to talk about non-patented technology. This committee believes, and has documented, that FQPSK stands for patented technology by Feher and Associates. I fully agree with Roger Samdahl, Chair of this committee, in this interpretation. This committee, unanimously, for the third time since May, after a request for re-consideration from the Plenary, voted yesterday again on this specification, which implies and includes the term FQPSK, which was understood by this committee to mean the patented technology. The current paper by Buass and Brown, the response to Plenary request to review IR PHY, basically shows that the requirements of the IEEE regarding IP have been satisfied. The performance is superior as measured by Eb/No and there is no alternative technology that comes close to its performance. The current document states that this is the best technology. There has been no reduction in the requirements. This committee stands behind FQPSK patented technology as documented in the one page summary 94/1XX. This document shows that in a power efficient environment, that it is the most critical requirement, power efficiency, is superior by to 15 dB. I'm assuming this memo could be read by our attorney. 6 dB in linear terms is 4 times the power, it is 4 times more power efficient than other technologies. Similarly, the difference in capacity is about twice or the nearest competition. These difference definitely justify the use of patented technology. The intellectual property has meet all the requirements of the IEEE head office, is offered at a reasonable price, on a non-discriminatory basis, actually the price which is negligible, almost free, so the holder and assignee of the patent rights and his corporations and associations believe that once the expert committee approves a standard, reviews it on order of the Plenary committee, that it is the believe that the assignees that if it is rejected by vote in what could be considered a strategic or political vote, that the alternatives might be a case for appeal."

LVDJ asked how many people in the room considered themselves to be expert in digital modulation techniques. Three of the twelve people in the room indicated that they felt they were expert. LVDJ then suggested that the assumption that this was an expert committee was questionable. Samdahl agreed. Feher disagreed, pointing out that many companies composed of experts have accepted it. LVDJ replied that other ad-hoc groups in the IEEE 802.11 have rejected this technology, however, he suggested that FQPSK is, in fact, close to what needs to be

done for IR. LVDJ again suggested that the best course of action was to specify a non-patented technology and "get on with it".

Valadas stated that, based on the submissions, he is convinced that FQPSK it the best technology.

Samdahl restated the issue, that we had previously voted to accept a patented technology, knowing that it was patented, and that that state of affairs has not changed, in spite of arguments and protestations from the Plenary.

Larry asked, for the record, if everyone realize that there comments were being recorded; everyone indicated that they had agreed to that previously.

Buaas returned to the statements in the /1XX paper and moved that the committee accept the document as a 'capture' of its judgments. Samdahl objected in a state of confusion. Feher suggested that this document be presented as an "accurate reflection of this committees endorsement". LVDJ asked for a short break so that he could get Don L to review what we were doing.

After the break.....

Feher initiated a motion for delivery to the PHY and Plenary. The discussion that followed was rich with amendments that modified the language but not the intent of the motion. As finally agreed to, the motion read:

"Resolved: After reviewing FQPSK as requested by the Plenary, the IR Sub-Committee recommends the adoption of this patented modulation for use in the carrier based IR Standard."

Moved by Feher, seconded by Buaas. LVDJ spoke against the motion, Feher spoke in favor and Betancor spoke in favor.

Samdahl spoke for the record, indicating that as chairman of the committee, he limited the submission of new proposals for new techniques in March. He suggested that we did not deliberate over other possible techniques that were not defended at that time. Dobyns pointed out that although the limitations were at the whim of the chairman, the committee could easily have overcome this limitation if that was their wish.

The question was called by LVDJ, seconded by Buaas, and passed. The motion passed 7,2,1.

The plan that was agreed to was for the paper /1XX would be read to the PHY (and Plenary) by Buaas and Brown, and the motion would be presented by the Samdahl, as the Chairman of the ad-hoc group.

Thursday AM, 7/14/94, IR PHY

Again the issue of the coexistence band was opened, and again there was no consensus at all. Valadas' insists that a risetime in the range of 0 to 40 nsec is required for proper 16 PPM communication with 250 nsec pulses, resulting in a 20 dB down point somewhere between 12 and 16 MHz. Although there are some of us, including your editor, who believe that this risetime is excessively sharp, it is part of the template and draft spec that have been accepted within this ad-hoc group and also passed on to and accepted by the Plenary.

The idea of replacing frequency isolation with spatial isolation as discussed on Tuesday was also revisited, again with Valadas and Samdahl supporting this concept and Blomeyer, Feher, Lopez-Hernandez and Betancor opposing.

A concern was raised by Valadas. When the FQPSK signal is passed through the non-linear transfer characteristic of the LED, there will be components created at low frequencies, in fact right down to DC. Samdahl pointed out that the transmitted IR is phase incoherent (phase referring here to the phase of the 850 nm IR signal itself). Therefore, any transmission mechanism will create energy at DC, and assuming fast frame and pulse risetimes, at other low frequencies that will most likely fall in the baseband region occupied by the baseband IR PHY. This may be a more severe interference problem than the effect of the baseband on the modulated carrier band. Lopez-Hernandez made and argument that the baseband IR signal could and should be constrained to drop below 20 dB before the coexistence band is entered (at 5 Mhz). It became obvious that there is some confusion in the minds of some committee members regarding the difference between the spectrum of the IR in the 850 nm range and the spectral pattern produced by modulation or encoding patterns. It was however, agreed that some experimental data would be of value. Lopez-Hernandez suggested that real world data would show effects that are not predictable by mathematical modeling, due to the motion of people and absorption and reflection characteristics of physical objects. Samdahl spoke to the difficulty of making meaningful measurements in real operating environments caused by the non-linear additions of physical effects.

Buaas asked several questions trying to resolve the confusion over spectral characteristics measured in the electrical domain versus those in the IR domain. He has asked for a description of the spectral pattern and dynamic range that would be observed at the receiver. Samdahl responded that in the commercial Photonics systems, dynamic range of measured signals runs through 30 to 40 dB and that the spectrum varies from a very shape, wide bandwidth signal for strong near field signals to soft, low bandwidth signals for distant transmitters that have undergone multiple wall reflections.

Valadas pointed out the current template for the modulated PHY results in a limitation of 4 frequencies in the 15 to 30 Mhz range, and that this is a severe limitation. Blomeyer agreed, stating that 6 independent bands allow optimized reuse of the medium in an open area where cells must, of necessity, overlap but not interfere.

Lopez-Hernandez spoke at some length about the signal levels that would cause interference to the modulated carrier system. Samdahl pointed out that the appeal of baseband systems is that they can be very inexpensive. It is admitted that with suitable levels of silicon integration it may be possible to build modulated systems that are equally inexpensive, but the fact remains that the cheapest systems will be at baseband and will spray signals over a relatively wide bandwidth. It was also pointed out that the competing IR systems, from Japan, IEC and IRDA are parsing up the whole 30 Mhz band are that it is unrealistic to expect that we can control this proliferation of IR that will compete with both the baseband and modulated carrier LAN applications.

Feher asked for another announcement to be read into the minutes:

> "I wish to inform this committee that yesterday I talked to Don Lochrie, chair of 802, with several people around, informing him of my current dissatisfaction and extreme concerns about how some statements are handled from this committee in the past by some individuals and some of the procedures of 802.11. I sought his advice in the procedural method of standardization. I left this meeting for about 20 minutes because I am going to Vic Hayes and John McKown of Motorola who are respectively the Chair and Vice Chair of the committee that today, from the side of the FQPSK proponents which is represented by numerous large and small corporations which was documented most extensively in modulation formats for 802.11 which was proposed first by Andromeda Corp. of Germany and I never knew them. They have done experiments as early as Nov `93, almost a year ago, since then the large corporations which are not voting members here, NTT, Siemens and Intel, all have multiple presentations interested basically in ..... I guess Roger Samdahl, our Chairman, yesterday confirmed that it was unanimously approved in May, also by the PHY, .."

Samdahl interjected that the PHY did not vote unanimously for FQPSK. Feher continued:

> "The PHY approved otherwise it wouldn't have been taken to the Plenary. Procedurally what happened was the that the Plenary sent it back to investigate whether this modulation technique is really what we are willing to go for a patented modulation technique. After extensive debate of this committee, and this committee is the infrared committee,
> supposed to be the only expert infrared committee within the 802. This committee, unanimously with a vote of 9 to 0 approved as stated, the statement we take today to the Plenary, and to the PHY, that even after the inquiry about the patented technology, it is the one that we really want. The vote was 9 to 0, yes. This infrared committee, its Chair and voting members, have been given all the intellectual property guidelines, and they know that the technique could be adopted only if patented if it is part of ... The vote was again 9 to 0. I just want to bring attention to the committee that I understand that there was a precedence in 802, several precedents of intellectual property that companies had to pay royalties. I understand that in this industry, most people who make intellectual property claims are trading patents and don't pay royalties. I was told informally

> by many members of the 802.11 that the main problem I'm facing is because I announced that our organization will charge a royalty, even the royalty is absolutely negligible, I'm making the statement it was announced that the cap per year which is a small fraction of the industry standard. I was told that in 802.5, HP created a similar issue by stating that they had intellectual property and they would not give it free and they will not trade. So I'm appealing to the committee here now in the following. First I wish to thank for there extremely strong support, 9 to 0, even if we were ordered by the highest level committee to reinvestigate the choice. Being today is ... that dragging out the vote to September, exhausting the resources of small companies, could lead to a binary decision to initiate a potential procedural action which would hopefully satisfy methods of both parties, not only of IEEE but also the proponents of the technology. In summary, I would hope that the Chairman of this committee who's going to move these things in about a half and hour or so to the PHY level, and in the Plenary level, considers that whether there is a conflict in the two PHY standards or not, that it is a full responsibility to represent the committees response enthusiastically as it has been in the baseband scheme. It's not our intent or Kamillo Feher's intent as an individual, to go into potentially long dragged out investigation which would stop any standardization for a couple of years. I hope it will sincerely not happen, but I believe in moral principals, as a fellow of the IEEE on procedural methods as I said to Vic Hayes, and I hope you people will support us without spoken comment and not try to coerce me by saying why don't you give up the FQPSK, and so forth. We are not prepared to do it."

Samdahl put up the slides that he intends to present to the PHY and then later to the Plenary, assuming that the PHY agrees.

Feher indicated disagreement and that he was continuing to tape his comments, stating:

> "Mr. Chairman, I object very strongly to making a resolution reflecting that the IR subcommittee voted the accepted technology 7,2,1. I think the accurate reflection the minutes reflected that FQPSK was adopted with a vote of 9,0,0. You agree with this?"

Samdahl responded, yes. Feher continued with his complaint, and Samdahl indicated that he would try to include a reference to the earlier vote when the motion was presented for the PHY and Plenary. Feher then asked that vote count and the phrase "unanimously" be added to the final slide.

The meeting was adjourned at 10 AM.