Tentative Minutes of the Direct Sequence PHY Sub Group, July 1994

IEEE 802.11 COMMITTEE

Tuesday Morning 7/12 Meeting commenced 8:40 a.m.
Chair: Paul Struhsaker; Secretary: Paul Pirillo
Attendance: The following attended most or all of the sessions of the DS PHY subgroup

Jan Boer - AT&T GIS
John Fakatselis - Harris
Maurice France - Radio Connect Corp (TGF)
Brian Mathews - Harris
Al Petrick - Harris
Paul Pirillo - AT&T GIS
Jim Roesch - Harris
Doug Schultz - Integrated RF Solutions
Don Sloan - Aironet
Paul Struhsaker - Aironet
Ken Talentino - Amphenol

Objectives
The DS PHY Draft Spec is document 94/050r2
three open sub-issues remain in the DS PHY spec
1. Frequency Channel Plan (relating to international frequency availability)
2. Eye Pattern
3. CCA (Clear Channel Assessment energy thresholds, etc.)

Paul S. summarized the open issues. The group will be working to fill in the holes in the draft document. Layer management for example. Where MAC/PHY has not given clear guidance.

There were no minutes generated from the May meeting. The group will basically be ratifying decisions made in May.

Channelization: Jan Boer presents channelization plan revisions. At last meeting a three-group plan was developed to avoid having a channel at the high edge of the band (FCC compliance concerns). Also more channels would be better for allowing network coexistence.
1. 2412, 2442 MHz
2. 2422, 2452
3. 2432,2462
4. 2484

For Europe only 5 channels are supported. The lowest frequency is not available. Japan allows only 2484 MHz. Paul S. explains need to add caveat that regulations take precedence over the standard.
CHN_ID parameter (i.e. 7 for DS, 75 for FH) presented to the MAC to help share parameters between the FH & DS PHY implementations. Jan B. moves to accept the channelization plan, Maurice seconds.
Unanimously approved

Eye Pattern: Paul S. shows the DS PHY amplitude vs. frequency mask. Dual conversion architecture is basically a requirement due to switching times, etc. that have been agreed on. So there is both baseband and IF filtering. The eye pattern used for compliance measurement is that taken through a reference receiver for which the receiver distortions are known and have been subtracted off.

Paul S. presents paper *DS PHY Transmit Eye Pattern Proposal.* The key parameters: Worst case Noise margin & Worst case timing jitter. Discussion of difference between tracking offset and timing jitter. Reference receiver needs to have knowledge of the transmit chip clock in order to calibrate out its own distortion. This is a TRANSMITTER test. Limiter and phase noise, as well as group delay properties of the receive baseband filter contribute to the overall timing jitter. Jim B. discussed non-multipath causes for I & Q peaks not being simultaneous (quadrature distortions). DC Offset, Amplitude imbalance, RMS jitter can be specified for each point in the constellation. It is agreed that the eye patterns are capable of revealing these distortions.

To fully account for both I and Q Paul S. suggests DC coupling the signals and then overlaying the Waveforms on a single eye pattern chart. The composite signal would then need to meet the amplitude and timing specs. Discussion of whether signals normally not exposed will need to be brought out for compliance testing in a lab environment. Paul S. takes a straw poll of acceptance of the eye mask test methodology. Majority approval. Continued discussion of the need for this type of test vs. doing nothing at all.

Jim B. again wants to be sure that any errors appearing on a constellation diagram will also appear on the eye pattern. i.e. VCO phase noise. Consensus that it does. Discussion continues as to when a constellation diagram test is desirable. Example is future PHY designs that use a higher-order constellation such as 8-PSK. In this case Paul S. says the test method will need to be revisited.

Paul S. outlines the details of the actual parameters being measured off the eye mask.
- Timing error
- Noise margin

How measurement is made:
1. Normalize the larger amplitude signal of either I or Q to +/- 1 volt and apply same normalize scale to the other channel. *per [1] of submission
2. Overlay I and Q (normalized) centered on the geometric mean of each signal.
3. Place mask at geometric mean of horizontal and vertical eye axis.
4. No signal trajectories will intersect the reference mask.

Effect of DC offset on the transmit signal is discussed. Paul S. explains that a carrier suppression spec will take care of DC offsets since a QPSK system will need at least 20 dB carrier suppression.

Extended discussion on where to extract the sample point used for making the measurement.

Paul S. suggests the following parameter values
Timing error +/-0.25Tc at least, 0.2Tc preferred
Noise margin: 0.75V margin (2 * peak eye closure = 0.5)

Discussion ensues on how repeating this process 11 times for a complete symbol produces an average result. Thus the single-chip mask number could be pessimistic. Phase noise etc. can quickly produce 0.2Tc timing error. DC offset: -20 dB carrier suppression may be too stringent. Perhaps 16 dB is more appropriate for commercial systems.

Decision made to continue with this issue to closure and get the text fine-tuned. Jan B. states that the group in the past has allowed time to study proposed specs before finalizing language to be used in the standard.

Modulation Accuracy.

"The worst case timing error shall not exceed 0.2Tc (chip period). The worst case noise margin as shown in figure x.x shall not exceed 0.75*normalized. The modulation accuracy conformance shall be made based on the following procedure.

a "pre" the eye patterns are based on an accumulation of 10,000 chips derived from all 1s data processed by the DS-PHY transmitter.
a. The eye measurements will be normalized to ideal binary states of +1 and -1 with the ideal signal level determined as 2 times the peak eye closure of the channel (I or Q) with the largest amplitude variation, plus the noise margin. Select the channel (I or Q) with the largest amplitude variation.
b. The gain correction factor used for normalization of the lesser amplitude variance signal shall be the same as [used for] determining in a.
c. Overlay the normalized I and Q patterns based on the zero reference center for each eye pattern. (i.e. the DC reference).
d. The horizontal placement of the center of the eye mask shall be (one half chip period) 0.5Tc away from the mean zero crossing position of combined eye patterns.
e. The vertical position of the center of the eye mask shall be placed at the zero reference center indicated part C above.

The reference receiver shall provide I & Q outputs under the conditions of carrier lock to the values of 45, 135, 225, 315 degrees.

Once the mask is placed no signal trajectories will fall within the eye mask for compliance to DS-PHY spec.

Consensus reached that this text may need updating based on comparison to what other specs are doing.

Paul S. moves to vote on including this text in draft standard 94-50r3 (issue will remain open). The plan is to present this at the September meeting. **Adopted unanimously**.

Carrier suppression: The transmit carrier suppression shall be at least -15dB from the sinx/x spectrum peak for all frequency channels specified for the DS PHY. The measurement shall be made transmitting all 1s through the DS PHY transmitter.

Paul S. notes that the language in the mask definition should be modified to say sin/ spectrum peak, and not dBc.

Maurice moves to open a new issue for transmit carrier suppression. Jim R. seconds. **Unanimously adopted.**

Paul P. moves to insert above text as a placeholder in the draft spec. Jan B. seconds. **Unanimously approved.**

Maurice moves to open TX mask issue, change text to reflect sinx/x peak and close issue. John F. seconds. **Approved unanimously.**

Clear Channel Assessment:
Paul S. leads discussion. For DS PHY the CCA is assumed to be code lock to another DS device. This is avoiding the issue of microwave ovens. The group needs to investigate a method for time sharing the channel with oven emissions.

Clear Channel: Expect that no transmitter is operating and that transmission will go through with low probability of collision and high probability of success.

There exists a threshold of interference above which one should never transmit because even if the message is received you will not be able to hear the ACK. Jim R. states that the UPCS etiquette exists as a precedent for a sharing scheme. Discussion of importance of minimizing the window during which another signal can come on undetected. Energy detect mode operates faster than code lock, but filtering is needed to avoid deferring needlessly after noise spikes, etc. Discussion of how to determine a fixed threshold before deferring to interference.

Discussion of what exactly the MAC is expecting from the PHY. Their desire is a single bit yes/no indication.

Paul S. charts...
-If a persistent high background noise level exists after some period of time (n backoffs) we will proceed with transmission even though threshold is exceeded.
- There exists a high threshold for which transmission should NOT be attempted because reception is impossible.

Meeting adjourned 5:30 p.m.

Wednesday 7/13/94 Meeting begins 8:30 a.m.

Brief discussion of implications of Tuesday night MAC/PHY rate change vote.

Group agrees to allocate 30 minutes to revisit the transmit Test Mask issue.

Jim R. has put together a paper on Modulation Accuracy issues and test methodology. This is a compilation of how TIA and IS-54 have approached amplitude imbalance and origin offset issues. There is also a paper on I/Q modulation alignment procedure including a BASIC program for use in calculating the quadrature phase error, amplitude imbalance, and LO leakage.

Paul S. speaks in favor of a constellation diagram approach to modulation error measurement.

Maurice raises question of where in time to sample the eye waveform. It is possible to pick a point on the eye diagram away from the center of the chip period where eye closure is reduced relative to the mid-chip value. This may produce misleading estimates of transmitter/receiver compatibility. Paul P. suggests locking in timing of chip period with a known (1010...) pattern, then transmit random data to create the eye diagram. Jim R. and Paul S. are becoming convinced that eye pattern is the way to go.

After continued discussion consensus is reached that constellation (I/Q) approach can be described to the user in a more straightforward manner.

Constellation Measurement
1. Determine sampling for chip clock by computing the mean zero crossing positions, then offsetting by 0.5 Tc (Tc = chip duration)
2. Sample constellation using clock phase determined in step one.
3. Compute DC offset.

4. Compute amplitude imbalance.
5. Compute RMS (average) (worst case/peak) Error Vector Magnitude
6. Subtract DC offset for all samples, then normalize by the mean magnitude.
7. Take magnitude of all normalized samples.

Paul S. and Jim R. outline use of a square rather than a circle at each of the 4 constellation points

Paul S. will clean up the description and distribute by e-mail to the group within two weeks.

Jim R. moves that Paul's text (above) be inserted as a placeholder for draft standard. Maurice seconds. **Unanimously approved.**

Jim R. opens discussion on redundant BER specs 10.4.8.1 and 10.4.8.6 by moving that we retain the spec for -80dBm sensitivity at 10e-5 BER and delete the other spec (17dB Eb/No). Specifically delete template item 27 and Standard item 10.4.8.6.(in document 94-50r2) Paul P. seconds. **Unanimously approved.**

Jim R. moves to change maximum input level text from "tolerate" to "provide a minimum 10e-5 BER at an input of -4dBm" (Template item 9, 94/50r2 section 10.4.8.2) Al P. seconds. **Unanimously approved.**

Paul S. opens discussion of CCA with state machine drawing.
CCA must be available continuously
2 states: clear, busy
Can't use a PHY_DATA req to set a backoff count.

Asynchronous state machine clocked by transitions on the energy detect input. This detects pulsed non 802.11 emissions (i.e. Microwave ovens). After N pulses in a given time period the channel can be declared clear. Paul suggests 10 usec energy detect latency. This spec already exists in the draft.

Suggested values for threshold parameters are discussed:
ED threshold - -67 dBm minimum. Probability of detection 99.9 percent. 10e-3 probability of false alarm. Jim R. wants to consider the cost of excessive deferrals vs. excessive collisions. Extended discussion concerning false alarm rates and whether only to set a minimum requirement and allow designers to go higher and allow more false alarms.
CNT/N - 15 msec +/- 3msec / N = 4
BIG - Discussion on whether to even implement this threshold due to the demands on dynamic range of the RSSI detection circuit. **Not implemented.**
ED Latency - 10usec antenna to busy indication

Paul S. suggests that we fold these values into the ED and CCA portion of our spec.

Jim R. moves to put the current description of CCA into the draft standard section 10.4.8.4 and template items 20 & 20a. Based on the state machine as drawn [reference overhead slide notes], the ED threshold, CNT, and N parameters listed above should be applied. Maurice seconds. **Unanimously approved.**

Operating specifications : Temperature specifications. 10.4.7.4 should be modified to remove the temperature ranges. Maurice moves that a temperature spec be put into 10.4.6 of the draft standard. Don't delete the 10.4.7.4 text. Jan B. seconds. **Unanimously approved.**

Meeting adjourned 12:05 p.m.

Thursday July 14, 1994 Meeting begins 8:30 a.m.

Paul S. leads the group through 94/50r2 to review for any errors and double-check the logic behind decisions made in building the spec. Discussion covers PLCP sublayer section.

Members of the sub-group will review the whole document for accuracy and completeness and communicate their findings via e-mail prior to the September meeting.

Adjourn at 10:00 a.m.

During the sub group meetings the following documents were presented and discussed informally; some are referenced in the text of the minutes (some are reprints of articles from other sources).:
1. *DS PHY Transmit Eye Pattern Proposal,* Paul Struhsaker
2. *Modulation Accuracy As Determined by Error Vector Magnitude,* Jim Roesch
3. *Probability of Detection & False Alarm Graph,* Jim Roesch
4. *Unlicensed PCS (UPCS) CCA Examples,* Jim Roesch
5. *Dedicated Display Monitors Digital Radio Patterns,* Al Petrick
6. Compilation of Overhead slide notes developed by the group, including CCA state diagram and constellation measurement procedure.