Suggested 802.11 High Rate PHY Technique

Harris High Rate data modulation demonstration

Standard Definition Issues

• 10+ MBps Physical Layer standard
  – Provide backwards compatibility to IEEE 802.11 at 1&2 MBps?
  – Separate or integrated section for higher rates?
• Limited bandwidth available in the ISM bands
  – Maximize bits/Hz
  – Desire at least 3 channels
• Meet FCC requirements for ISM bands
  – FCC is comfortable with any solution that derives >10 dB from spreading function and passes CW test
  – Preliminary testing shows that the Harris technique will pass
• Textbook technique available without patent issues.
Harris High Rate 802.11 Features

- Provides 10+ MBps wireless LAN data rates while maintaining interoperability with 1 & 2 MBps WLANs
- Increases data rate by ≥5x with no increase in the transmit bandwidth requirement
  Rate switching during packets is supported already
- 1, 2, 5.5, &11 MBps capability
- Fits in a PCMCIA package, uses existing RF and IF

Suggested Technical Approach

- Utilize MOK/PSK modulation techniques to realize 4 to 8 bits/symbol
- Use existing preamble and header to insure interoperability.
- Increase symbol rate to 1.375 MSps (8 chip symbols) and hold existing spread rate
- Use existing 802.11 DS parts for the RF & IF circuits
Additional Modifications to Standard

- Use last bit of PLCP header as an absolute phase reference for high rate demodulation.

Performance Predictions

- MOK modulation is slightly more efficient than BPSK due to embedded coding properties. Theoretical performance is 7.8 dB Eb/N0 for 1.0e-5 BER.
- With 8 bits per symbol, Es/N0 is 16.8 dB.
- Should readily meet -80 dBm sensitivity but, we might want to spec it at -75dBm to provide margin.
- Will pass FCC CW jamming test with margin
  - J/S suffers with higher Es/N0
  - FCC allows SNR to be defined as Es/N0
Effects of Long Preamble

- The use of the interoperable preamble will reduce the average data rate.
- Longer packets will be less impacted.
- Overall network loading will impact the effective rates.
- A high rate preamble would alleviate these effects, but would eliminate interoperability.

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### Effective rate versus packet size for short preambles

![Effective Rate Graph](image)

**Effective Rate**
(11 Mbps payload rate, high speed preamble, no backoff, fast ACK, compatible IFS)

### Loading Effect Assumptions

- **RetryMax**=6, all transmissions are either successful or abandoned after RetryMax retries.
- Load is the probability that the medium will be busy when sensed.
- CCA is perfect and all stations can hear every other station (no transmissions are clobbered by hidden node problem).
Effective rate versus loading

![Graph showing effective throughput under load](image)

**Modulation Scheme**

- 802.11 DSSS Bpsk
  - 1 Mbps
  - Barker
  - BPSK
  - 1 bit encoded to 2 code words
  - 11 chips
  - 1 MSp/s

- 802.11 DSSS QPSK
  - 2 Mbps
  - Barker
  - QPSK
  - 2 bits encoded to 4 code words
  - 11 chips
  - 1 MSp/s

- 5.5 Mbps QMBOK
  - 4 bits encoded to 16 code words
  - 8 chips
  - 1.375 MSp/s

- 11 Mbps QMBOK
  - 8 bits encoded to 2x16 code words
  - 8 chips
  - 1.375 MSp/s
MOK Modulation Approach for 11 MBps

Data Rate = 8 bits/symbol * 1.375 MSps = 11 MBps

MOK properties

• This modulation is the most power efficient available
• The spectrum is like 802.11 DSSS
• Multipath performance is nominal for the SNR
• Requires a cover sequence to avoid the Wall0 CW modulation (modified Walsh Functions)
• Requires coherent processing
• Moderate implementation complexity (~25% extra)
MOK Modulation Approach
for 5.5 MBps

Data Rate = 4 bits/symbol * 1.375 MSps = 5.5 MBps

5.5 MBps properties

• The 5.5 MBps mode uses BPSK modulation which is much more rugged than QPSK
• This modulation will achieve comparable range to the 2 MBps QPSK 802.11 mode.
• Stations can easily fall back to this mode when stressed, then 1 MBps if really stressed.
Submission Carl Andren, Harris Semiconductor

HFA 3860 BER performance

![BER Performance Graph]

HFA 3860 PER performance

Packet Error Rates for 11 MBps

![PER Performance Graph]

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BER versus Clock Offset Performance

- BER versus Carrier Offset Performance

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Processing Gain test results

- Frequency offset vs. Processing gain

Propagation Simulations

- Simulation results show probability of a missed packet.
- 100 trials per point
- Packet length = 200 symbols
- 3 bit A/D: Carrier and Chip Loops active
- Dual Antenna Diversity (assuming no correlation)
- SAW is 3-pole Butterworth over passband and 50 MHz 30 dB BW

- Probability of Missed Packet vs. Tx - Rx Distance in feet

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