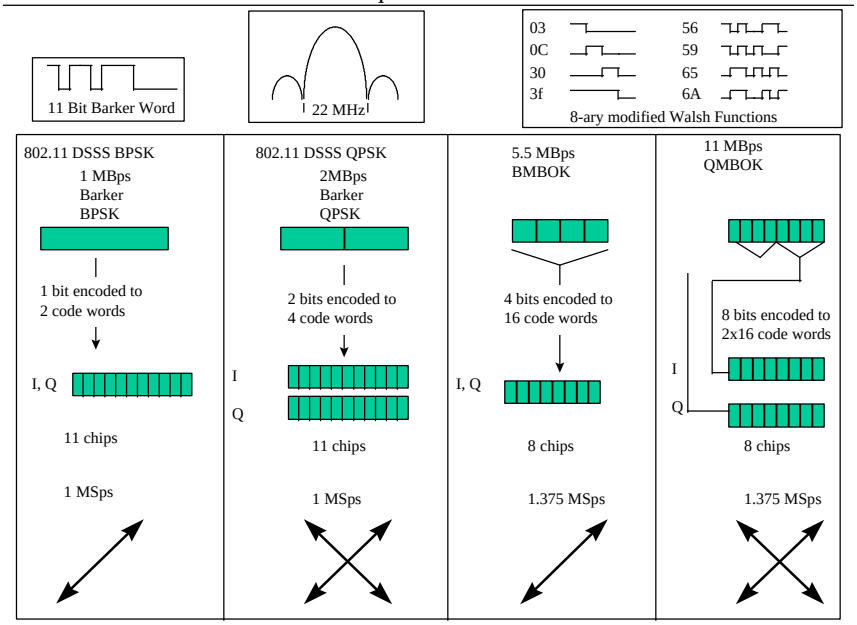
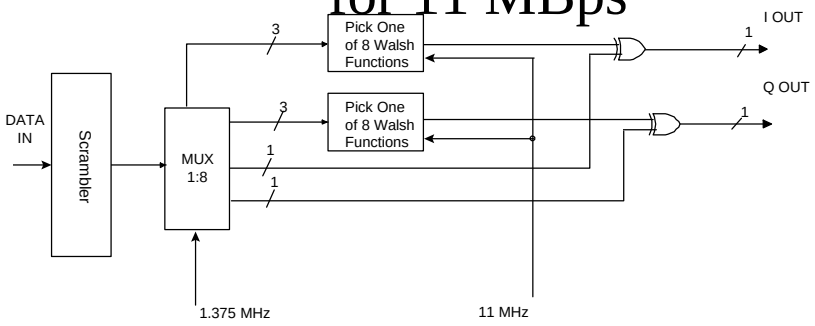
2.4 GHz High Rate PHY

Harris Submissions
for Comparison Matrix

Submission **Carl Andren, Harris Semiconductor**



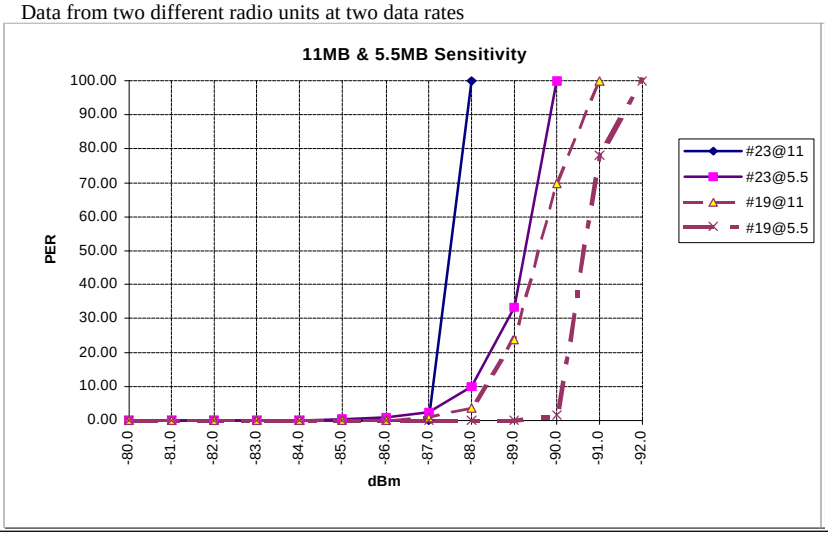
QMBOK Modulator Technique for 11 MBps



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

Receiver Sensitivity

Data from two different radio units at two data rates



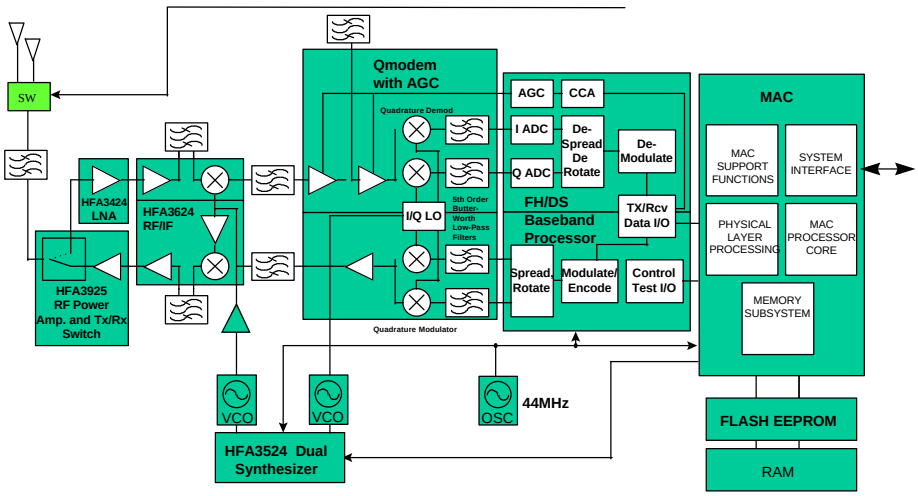
Reference Submissions

- 70254 IEEE 802.11 High data rate PHY extensions
- 70867 Suggested 802.11 High Rate PHY Technique
- 71447 Proposed 802.11 High Rate PHY Technique
- 80467B Harris 2.4 GHz short proposal
- 80477B Harris 2.4 GHz full Proposal

RF/IF Complexity relative to current low rate PHY

- Basically uses same RF and IF as existing 802.11 DS PHY
- Equalized version replaces the IF limiter with AGC and has more A/D converter bits.
- A combined DS/FH mode uses non optimal wideband IF filters with some loss of performance in a crowded environment

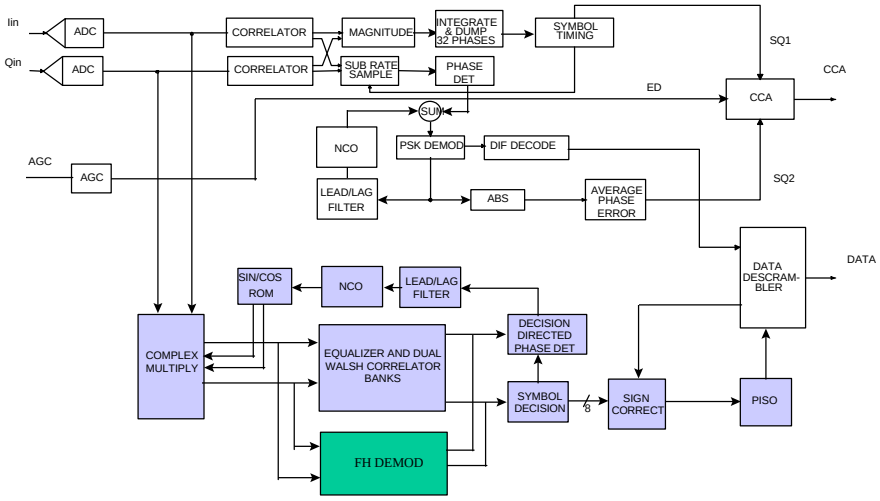
Receiver Structure Description



Baseband Processing Complexity relative to current low rate PHYs

- Addition of high rate without equalizer increases the DS interoperable only baseband processor complexity from 23K gates to 33 K gates
- Addition of equalizer to increase delay spread from 30 to 100 ns takes an additional 40 K gates

DEMODULATOR BLOCK DIAGRAM

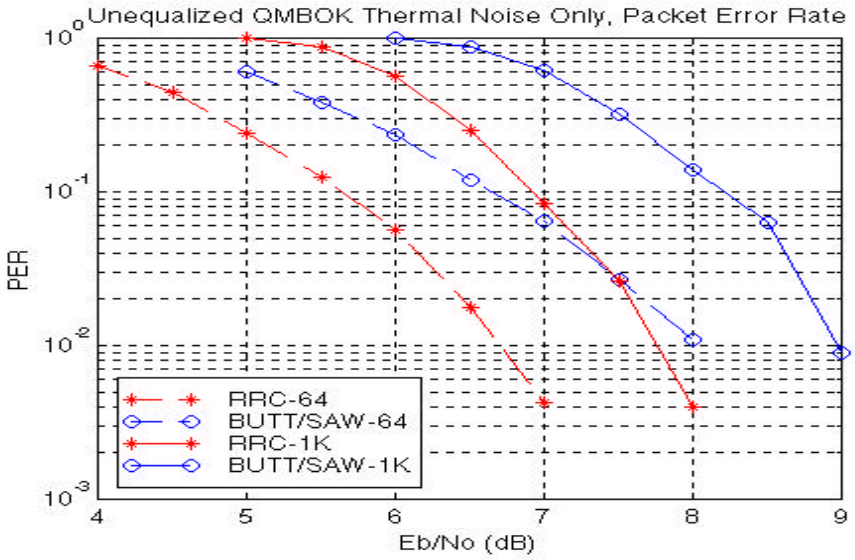


SHADED BLOCK ARE THE ADDITIONS TO DS FOR FH AND HIGH RATES

Antenna Diversity and performance impact

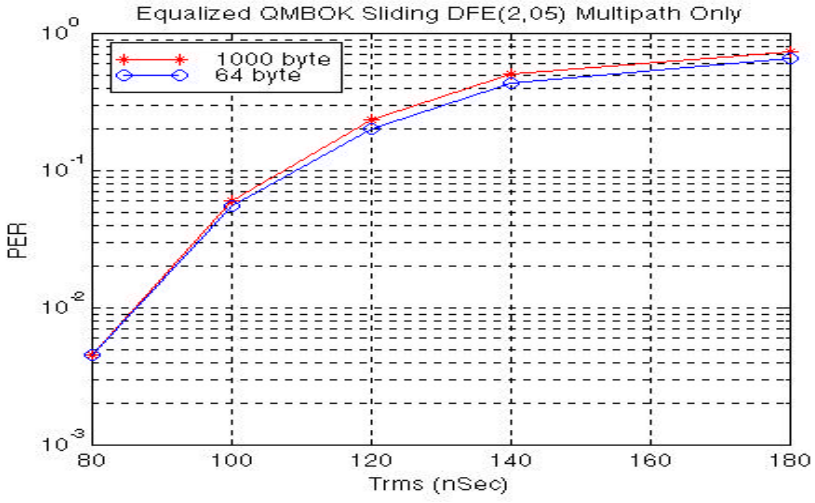
- Antenna diversity can improve the performance of the link more cheaply than an equalizer but not as much
- The performance impact has shown an improvement of a factor of 2 to 4 in PER in field testing
- The negative impact is to require additional time in the preamble on the order of 10 us (already covered by the 802.11 preamble)

Graph of PER Vs. Thermal Noise (no Multipath).

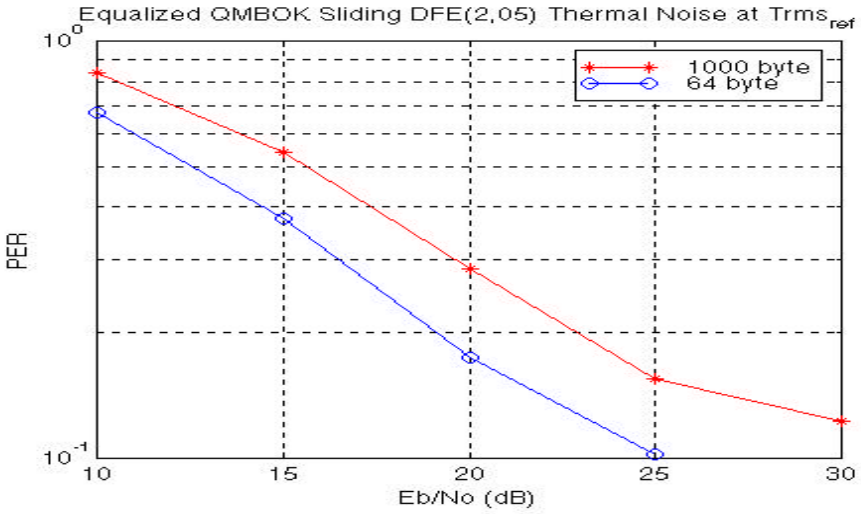


PER Vs. Multipath Only (No Noise).

- Equalized (2 Feedforward and 5 Feedback



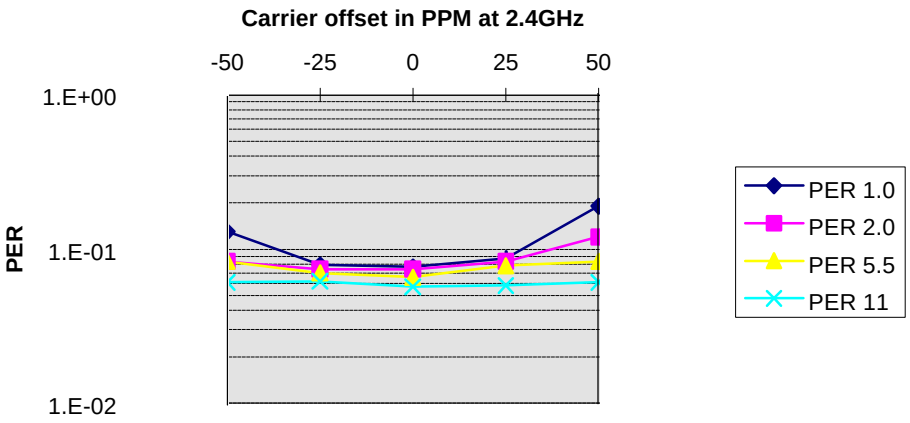
PER Vs. Thermal Noise with Multipath at 10% PER. Eb/No at 20% PER for 64 and 1000 byte packets.



Required Carrier Frequency Accuracy

- The new high rate PHY requires the same carrier frequency accuracy as the existing low rate PHY.
- The DS limitation is that the maximum carrier frequency offset should be less than 1/8 Th of the symbol rate of the preamble.

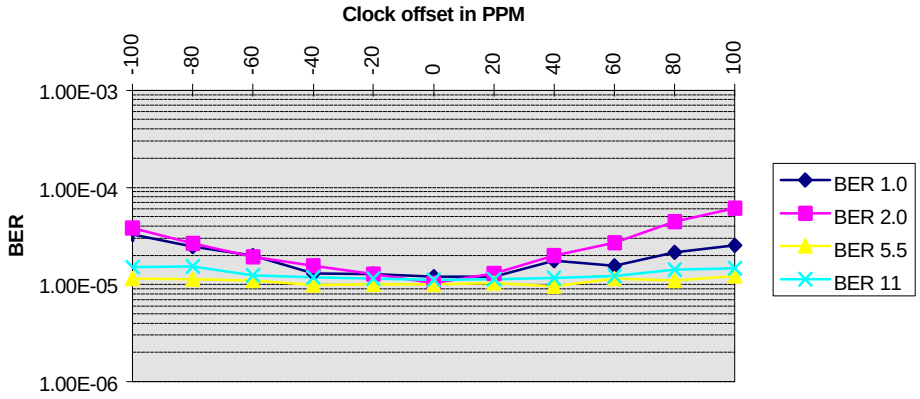
BER versus Carrier Offset Performance of HFA 3860



Required Data Clock Frequency Accuracy

- The new high rate PHY requires the same clock frequency accuracy as the existing low rate PHY.
- The limitation is that the maximum data clock offset should drift more than 1/8th of a chip in 128 us.

BER versus Clock Offset Performance of HFA 3860



Preamble Length

- Our basic approach is to include the standard DS or FH 802.11 preamble and header
- This length includes ample time to do diversity and equalization
- For the cases where interoperability is not an issue, a short, high rate header can be used.
- Antenna diversity and equalization require a

Slot Times

- We propose no change in the DS PHY slot time of 20 us or FH slot time of 50 us.

CCA mechanism and Co-Channel signal detection time

- We measure the correlated signal energy in the preamble over 10 us dwells beginning when the receiver is enabled and compare that to a threshold
- FH detection is done on clock energy in similar dwells.

RX/TX turn around time and SIFS

- The transmitter has a 1.3 us processing delay from bits in to bits out the antenna
- The receiver has 3.3 us processing delay from bits in the antenna to bits out
- The RX/TX turn around time is less than 2 us exclusive of the above delays.
- We propose the existing DS 10 us SIFS

Channelization Scheme

- We propose the existing DS channelization scheme.
- Three non overlapping channels in the band
- A choice of 5 MHz channel centers with 13 channels in the ISM band for the US.

Adjacent Channel Interference Rejection

- 8 dB more filter skirt rejection is needed to achieve the same ACI rejection as the existing low rate PHY

Co Channel Interference Rejection, DS

- The ability of the modulation to tolerate other networks in the area was tested. The results are S/J in dB that causes 5% PER

Signal → / Jammer ↓	1	2	5.5	11
1	6.2	7.6	6.9	8.7
2	4.2	6.5	4.0	6.7
5.5	0.9	4.9	3.0	7.9
11	0.9	3.1	1.9	6.8

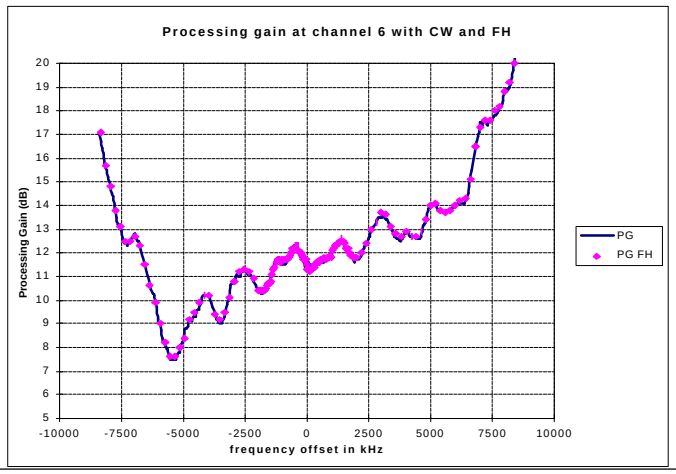
This indicates that the worst case Jammer for 11 MBps is the 1 MBps waveform that spoofs the preamble.

S/J where CW jammer gives 10% PER

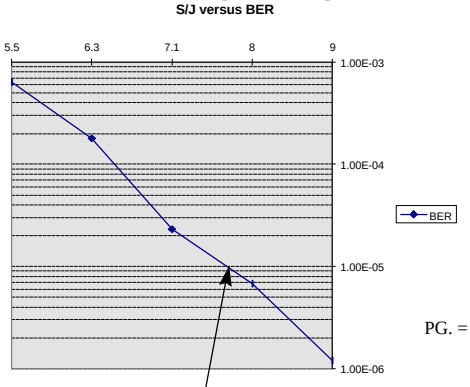
Data shows that the performance is virtually identical with FSK and CW Jamming

Note: channel 1 data is better

The 20% discard point is 10.3 dB



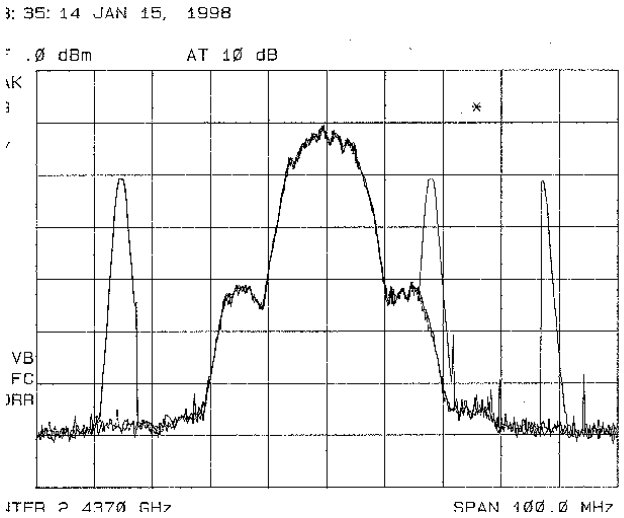
Other Interference Immunity tests, WB Noise Jamming Margin



PG. = 16.6 + 2 - S/J = 10.9dB

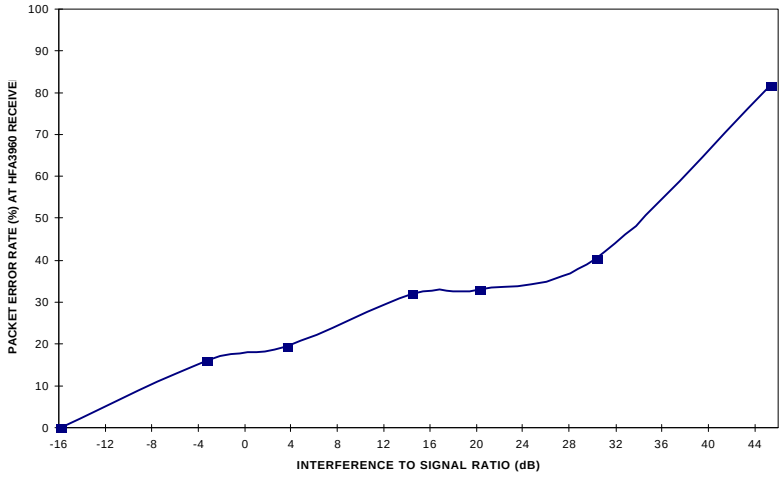
Note: Processing Gain is measured at the 1.0e-5 BER point
S/J is measured in spread rate bandwidth

Other Interference Immunity tests, FH



Other Interference Immunity tests, FH

Figure 6.4.1-2 PER VERSUS FREQUENCY HOPPING INTERFERENCE
Breeze Net FH Transmitter at 3 Mbps Interfering HFA3860 11-Mbps Link on Channel 6



Total Number of Channels in the ISM band

- We propose the existing DS channelization scheme.
- Three non overlapping channels in the band
- A choice of 5 MHz channel centers with 13 channels available. The highest two are not currently used by the existing standard in the US.

Aggregate Throughput

- The 3 non overlapping channels at 11 Mbps will allow 33 MHz total maximum achievable throughput in the ISM band.

Phase Noise Sensitivity

- There is no more phase noise sensitivity with the proposed waveform. It performs as well in phase noise as any QPSK scheme.
- The measured phase noise of our receiver's LO which performs well is 3 degrees RMS
- Our design was simulated to handle 8 degrees RMS

RF PA Backoff

- The QMBOK waveform needs about 5 dB of PA backoff to insure compliant regrowth of spectral sidebands.
- This is the same as the DS BPSK preamble requires

DC power consumption

- The current, non equalized HFA 3860 QMBOK chip draws 30 mA at 3 VDC.
- This represents about 12% of the radio receive power.

Patent Submissions

- The Harris position is that we will only patent techniques having to do with our implementation
- Anything likely to be embodied in the standard will be free of license from Harris
- The QMBOK waveform is public domain

Interoperability / Co-existence strategy with current low rate PHYs

- Interoperable via use of existing low rate preamble and header, either DS or FH
  - In the case of the FH PHY, the low rate preamble and header must be followed by a short high rate header to re-establish antenna diversity and to train the equalizer
- Will defer or cause deferral via 802.11 mechanisms currently in place.

Is the proposal Interoperable at the data level?

- Yes

Is the proposal Interoperable at the antenna level?

- Yes, the use of the existing preamble and header insures interoperability

Performance penalty due to Interoperability / Coexistence.

- The DS overhead is 192 us Vs about 50 us without interoperability
- The FH overhead is 128 + 10 + 50 us or about the same
- This amounts to ~20 % on 1K byte packet

Performance penalty due to Interoperability / Coexistence.