Simulation results for several WLAN Modulation Methods

Naftali Chayat and Michael Rothenberg
LANNAIR inc.
Tel-Aviv, ISRAEL

Introduction

The FH wireless LAN industry needs an agreed modulation method to promote interoperability. The method should compose a reasonable tradeoff between performance and the ability of the industry to undertake the implementation of it at a reasonable effort and price. On the other hand, the standard should promote future applications which require higher bit rates. The intent of this paper is to examine and compare several modulation methods.

The modulation methods to be compared fall into two main categories: FSK modulation, with varying prefiltering and deviation factor (propositions of Motorola, Proxim, N. Silberman, and Lannair), and coherently demodulated modulations (F-QPSK, by K.Feher, and FLOQAM, by Lannair), which are also constant envelope and are tolerant to limiting both in the transmitter and in the receiver IF chain.

Definitions and remarks

- The symbols and the symbol rate **Fs** in the case of Offset Quadrature modulations refer to a pair of In-phase and Quadrature bits.

- The modulation factor **h** for FSK is defined as a ratio between consecutive frequencies and the symbol rate, i.e. in four level FSK the peak to peak deviation is **3 h Fs**

- The ACI (adjacent channel interference) is computed by integrating the splatter over the whole channel, which is equivalent to a brickwall IF filter, to avoid assumptions about specific IF filters. In the receiver implementation suggested by Motorola, with an IF filter wider than the channel width, the ACI is expected to be significantly higher.

- The use of very low deviation FSK creates a very narrow bandwidth transmission, but it still requires an IF filter of a width of at least about 1.5Fs, otherwise an intolerable ISI (eye closure) will be introduced. The meaning of this is, again, an adjacent channel interference significantly higher than quoted in the table.

- The table assumes that the FCC bandwidth definition is fully utilized and the bit rate is as high as possible. In practice the bit rates will be 5-10% lower, to allow implementation degradation and frequency accuracy. This should improve the ACI with respect to the data in the table.

- The table does not include the effects of imperfect filtering or carrier frequency mismatch. The simulation was performed with idealized filters.
- Lannairs 4-FSK and 8-FSK modulations are adapted to demodulation by coherent methods. In this case there is a 3 dB gain (see numbers in parenthesis in the C/N @ 1 MHz).

Conclusions

- The 4-FSK allows better throughput than 2-FSK, while maintaining a comparable sensitivity (as per N. Silberman).
- The coherent demodulation methods enable to improve the throughput relatively to the noncoherent demodulation, while preserving the sensitivity and the constant envelope property.
- There is a tradeoff between the deviation factor **h** and the shape of the premodulation filter. A more complete discussion of the interrelation between the pre-, post-, and IF filters will be presented in a separate submission.
- The 20 dB bandwidth does not by itselt imply that a narrow IF filter can be used. The minimal IF filter bandwidth is related to symbol rate and not to the 20 dB bandwidth.
- F-QPSK offers improved sensitivity and robustness, at the expense of bit rate.

Appendix A: FLOQAM description

FLOQAM stands for Filtered Limited Offset Quadrature Amplitude Modulation. The transmitted signal has the following properties

- The I and Q symbols are ternary (3 levels)
- The I and Q symbols are staggered by 1/2 symbol interval
- The I and Q components employ square root raised cosine spectral shaping with shape parameter alpha=0.5
- Transition rules are imposed on ternary symbols to avoid amplitude dips (each 16 bits are transformed into 13 ternary symbols).

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Appendix B: LANNAIRs FSK proposition

LANNAIRs FSK proposition includes:

- Spectral square-root of raised cosine with rolloff factor 0.5 in the Tx premodulation filter and Rx postdiscriminator filter
- Additional preemphasis (about 1 dB at 1/2 Fs) on the transmit side and a corresponding deemphasis on the receive side.
- The modulation factor is kept as 0.6667/M, where M is 4 or 8 correspondingly (a document to be submitted).
- The shaping emlployed allows coherent demodulation (by DSP methods) with 3 dB sensitivity improvement.

Appendix C: Graphs of the power spectra

The PSD graphs presented later are at 10 dB/div (vertical axis) and 4 div/channel (horizontal). The divisions 3-6 correspond to the first adjacent channel and the divisions 7-10 correspond to the second adjacent channel.

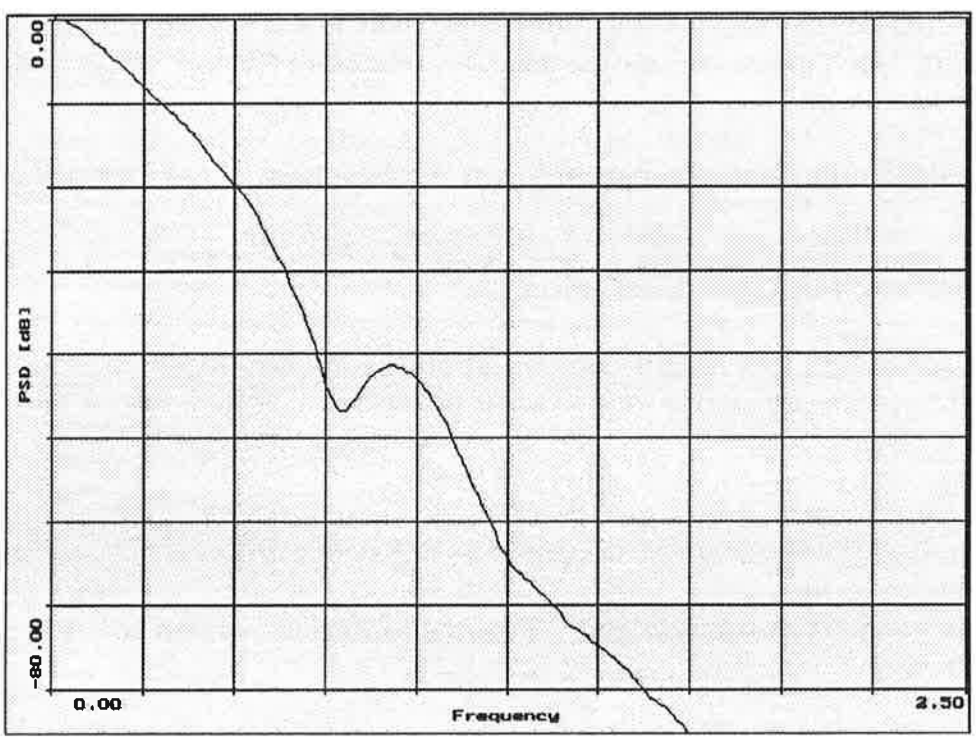

Figure 2: PSD of Motorola's 2-FSK (Gaussian BT=0.5, h=0.35)

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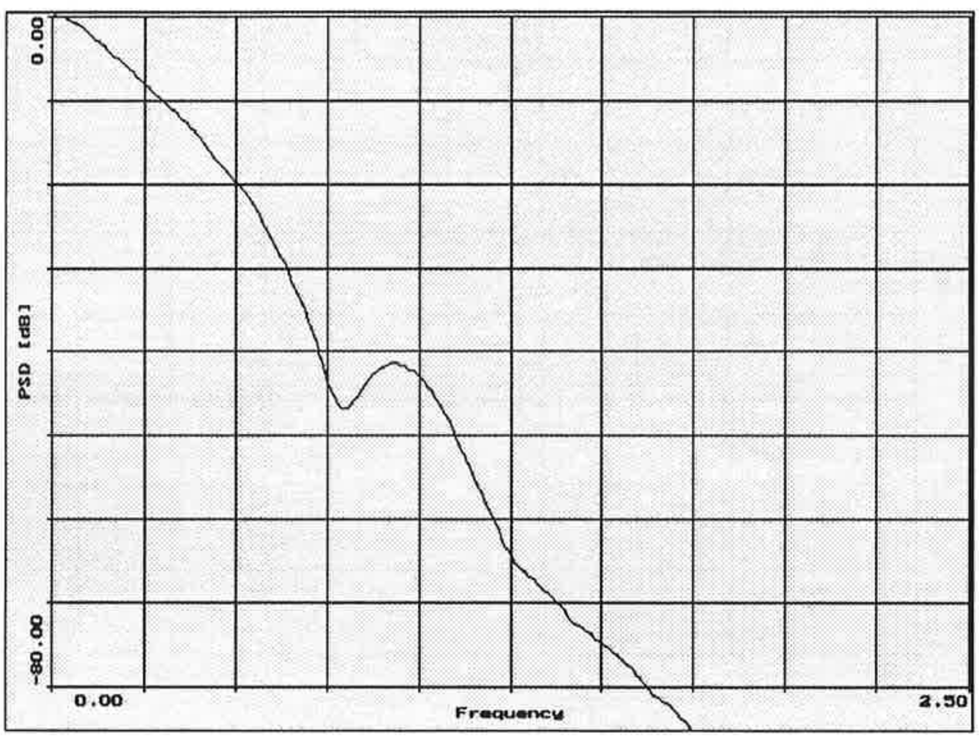

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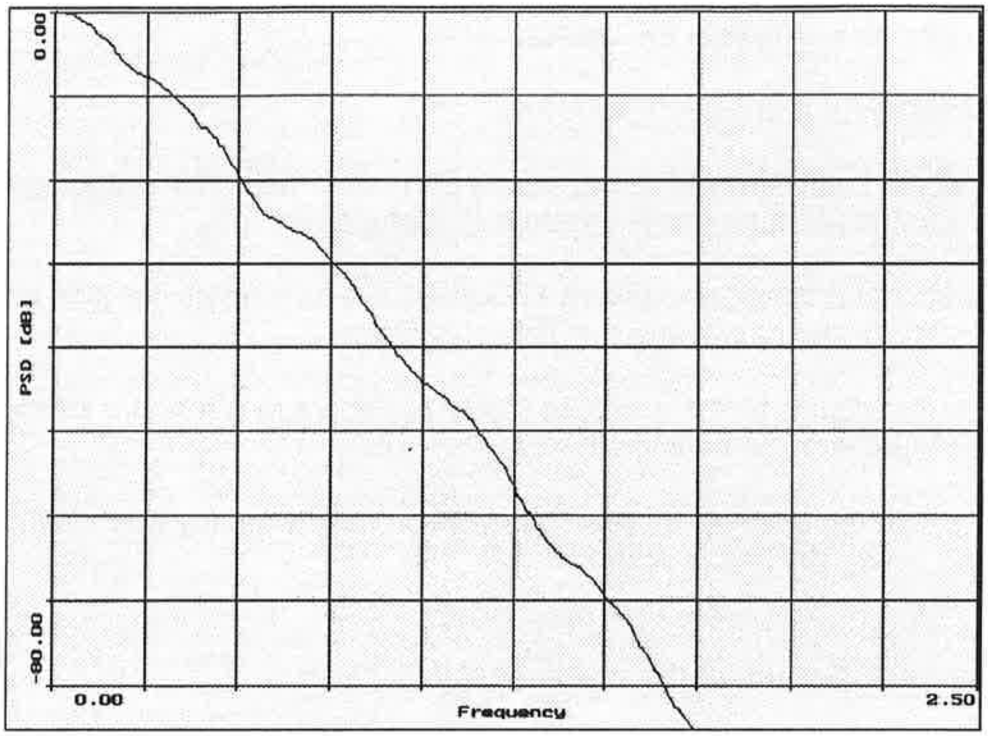


Figure 5: PSD of LANNAIRs 8-FSK (preemphasysed sqrt rolloff, h=0.0833)

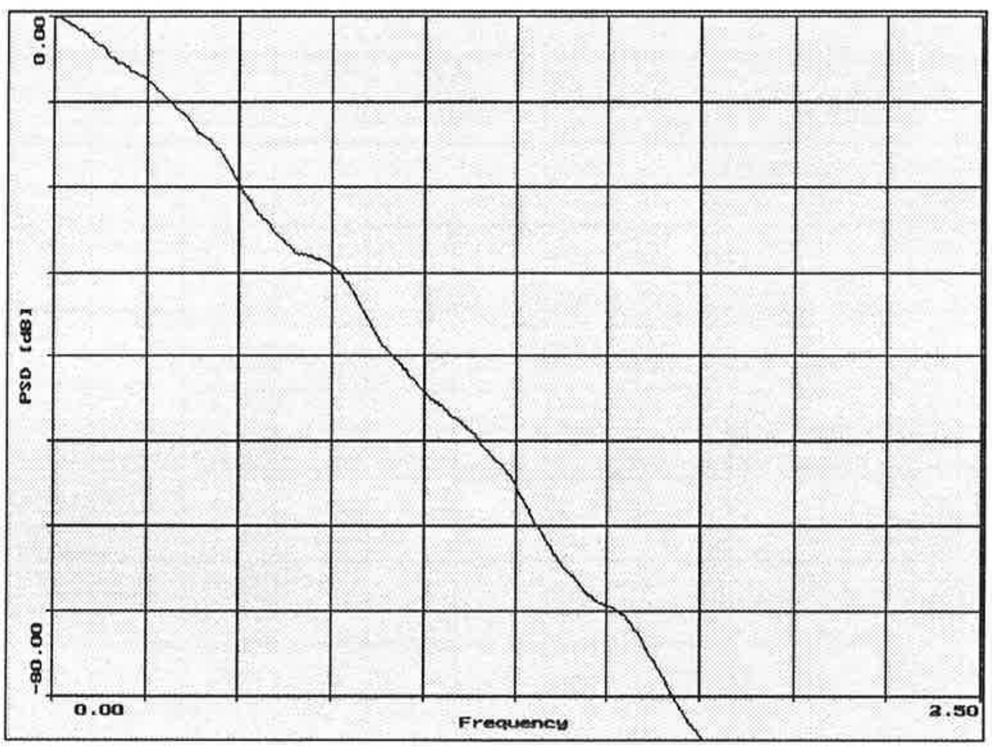
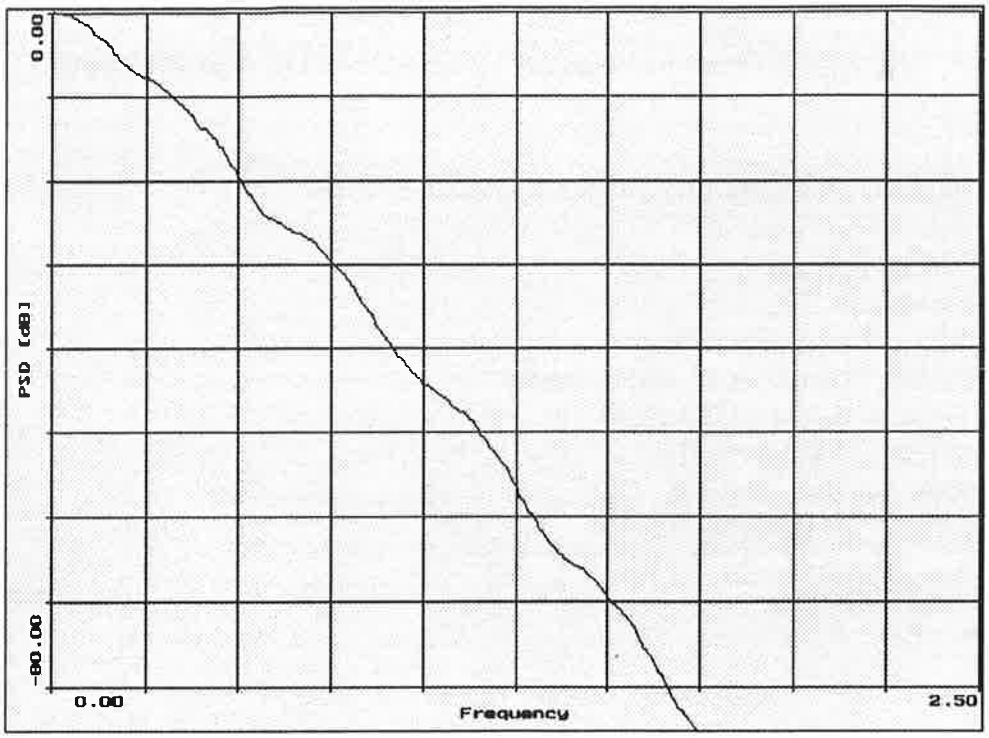


Figure 6: PSD of LANNAIRs 4-FSK (preemphasysed sqrt rolloff, h=0.1666)



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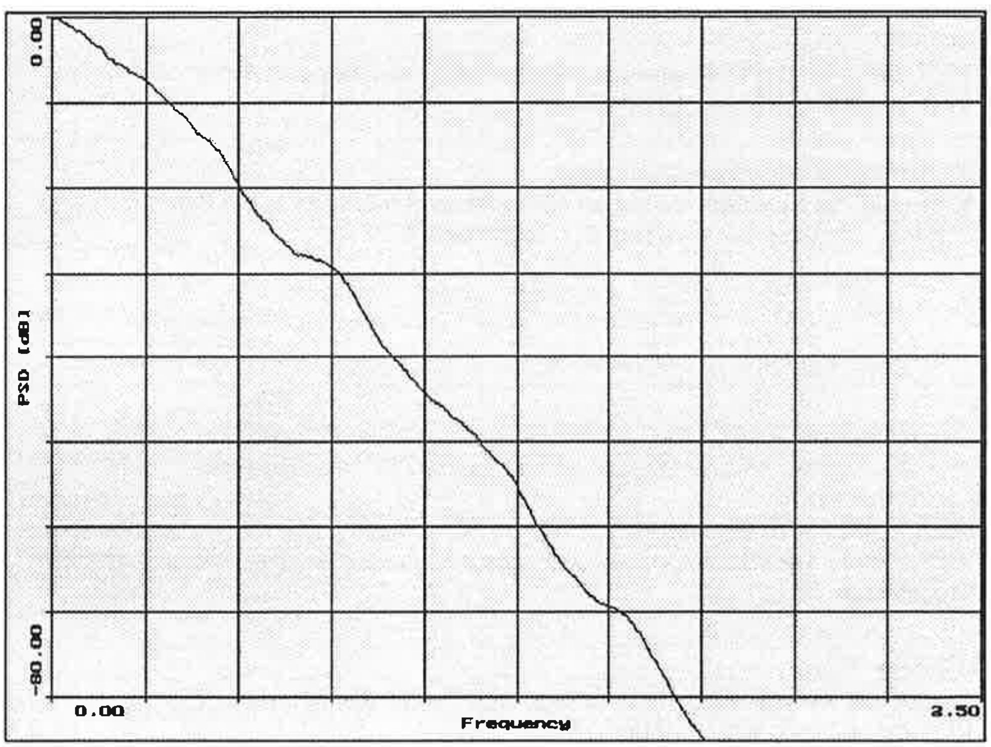

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