IEEE 802.11

WIRELESS ACCESS METHODS AND PHYSICAL LAYER SPECIFICATIONS

Title: **Proposed Modulation and Data Rate for Higher Speed Frequency Hopped Spread Spectrum (HS-FH-SS) Standard**

Author :   Yanpeng GUO   Hongying YAN
Digital Communications Research
Laboratory (DCRL)
Department of Electrical and Computer
Engineering
University of California, Davis
Tel : 916-752-4608
E-mail : yan@teak.ece.ucdavis.edu
Fax : 916-752-8428

Kamilo FEHER
Department of Electrical and Computer
Engineering
University of California, Davis
and
Digcom. Inc.
Tel : 916-752-8127

1. SUMMARY

- To increase data throughput, reduce message delay and to specify a robust High Speed FH-SS system, we recommend the adoption of 1.4 Mb/s as a standard data rate. OQPSK and compatible non-linearly amplified (NLA) power and spectrally efficient FQPSK modem techniques is recommended.

- It is demonstrated that the 1.4 Mb/s rate is more robust and leads to higher throughput / reduced message delay than any other 1.5 Mb/s (or higher) rate non linearly amplified (NLA) systems.

- User vendor bits or other designated bits in the PHY or MAC enable the switch over from the standard FH-SS 1 Mb/s rte (GFSK) to the higher bit rate systems.

Table 1.   Modulation Formats Considered by the FH and HS-FH IEEE 802.11 Committee as of January 9, 94

	Originator	Modulation parameters	Reception method	Bit Rate in 1 MHz BW	E_b/N_o @ 10^{-5}	Notes / References
4-FSK	N. Silberman (California Micro)	RC-2 filter h=0.25	limiter + discriminate + post-filtering + 4 level slicer	1.4 Mb/s	17 dB	Multi-level eye-diagram, disadvantage. [23]
4-FSK	Proxim	Gaussian filter BT=0.5, h=0.1666	limiter + discriminator + post-filtering + 4 level slicer	1.92 Mb/s	22.5 dB	Multi-level eye-diagram, disadvantage. [23]
8-FSK	Lannair	Pre-emphasis + sqrt roll off α=0.5, h=0.0833	limiter + discriminator + post-filtering + 8 level slicer	2.25 Mb/s	21 dB	Multi-level eye-diagram, disadvantage. [23,24]
4-FSK	Lannair	Pre-emphasis + sqrt roll off α=0.5, h=0.1666	limiter + discriminator + post-filtering + 4 level slicer	1.5 Mb/s	17 dB	Multi-level eye-diagram, disadvantage. [23,24]
FLOQAM	Lannair	See IEEE P802.11 93/135	limiter + coherent demodulator	1.72 Mb/s	16 dB	Multi-level eye-diagram, disadvantage. [23] Withdraw(?)
FQPSK(kf-dj	UC Davis	FQPSK-KF processor a=0.6 DJ filter JR=0.01,α=0.5	limiter + coherent demodulator + 2 level slicer	1.41 Mb/s	14 dB	2 level eye-diagram. 1 Watt. [1-7, 10-13, 16, 17, 19-22]
FQPSK-1	UC Davis	FQPSK processor	limiter + coherent demodulator + 2 level slicer	1.1 Mb/s	10.5 dB	2 level eye-diagram. 1 Watt. [1-7, 10-13, 16, 17, 19, 20]
GFSK	Motorola	7th order Bessel filter, BT=0.5, Deviation =160 kHz	limiter + discriminator + post-filtering +2 level slicer	1 Mb/s	19 dB	Adopted standard. 2 level eye-diagram. 1 Watt. [9, 8, 14]
π/4 DQPSK	??	sqrt RC filter α=0.2	coherent demodulator + 2 level slicer	$\geq$ 1.6 Mb/s	13 dB	**Linear. Power limit 150 mw. [13]**

As compared to 1.4 Mb/s proposal, all proposed Non-linearly amplified modulation schemes with 1.5 Mb/s or higher data rate which can attain 1 watt (instead of 150 mw) have at least 3 dB E_b/N_0 degradation at $P_e = 10^{-5}$.
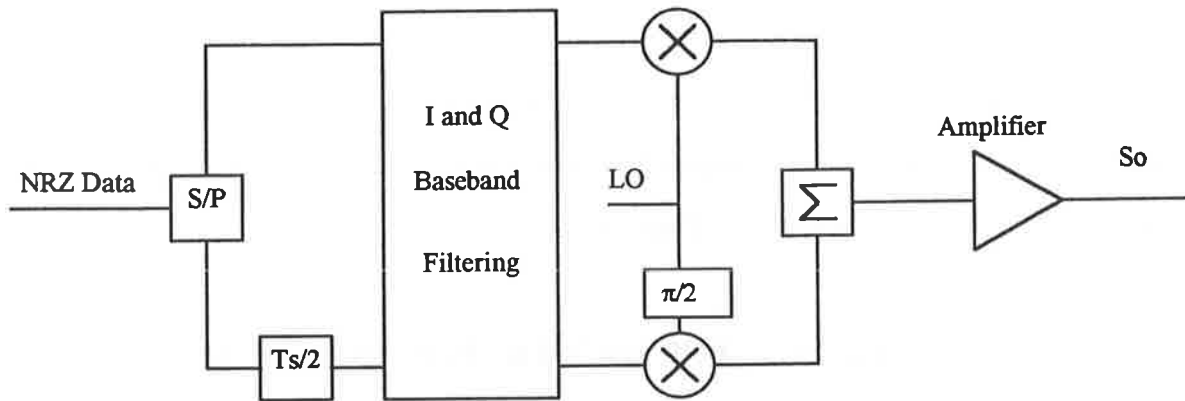
Figure 1. Block Diagram of standard OQPSK Modulator (such as adopted by the DS-SS IEEE 802.11 committee) and of compatible NLA (Non-linearly Amplified) FQPSK.
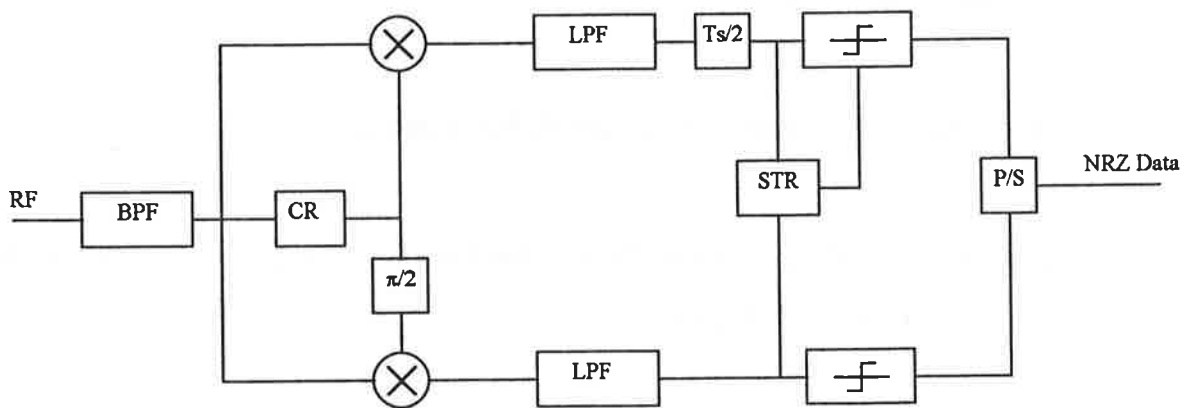

Figure 2.   Block Diagram of standard OQPSK Demodulator. The implementation of the FQPSK demodulator is identical with the compatible OQPSK. The DQPSK and OQPSK software switchable standard are described in reference [27].

The offset QPSK or OQPSK standard and the fully compatible non-linearly amplified FQPSK technique are described in detail in Reference [1-7, 10-13, 16, 17, 19-22].

6. K. Feher : " FQPSK : A modulation power efficient RF amplification proposal for increased spectral efficiency and capacity GMSK and $\pi/4$-QPSK compatible PHY standard," Doc. IEEE P802-93/97, Denver, CO, July 13, 1993.

7. S. Kato, S. Kubota, K. Seki, Ta. Sakata, K. Kobayashi, Y. Matsumoto : " Implementation architecture, suggested preambles and VLSI components for FQPSK, offset QPSK and GFSK standard 1 Mb/s rate and for higher bit rate WLAN," a submission by NTT-Japan, Doc. IEEE P802.11-93/137.

8. J. Socci : " GFSK as a modulation scheme for a frequency hopped PHY," a submission by National Semiconductor, Doc. IEEE P802.11-93/76, Denver, CO, July 13, 1993.

9. J. McDonald : " Discussion of modulation parameters of the 2.4 GHz FH PHY," a submission by Motorola, Doc. IEEE 802.11-93/102, Denver, CO, July 13, 1993.

10. Leung, P. S. K., K. Feher : " FQPSK -A Superior Modulation Technique for Mobile and Personal Communications," IEEE Transactions on Broadcasting, Vol. 39, No. 2, June 1993, pp 288-294.

11. Leung, P. S. K., K. Feher : "F-QPSK - A Superior Modulation for Future generations of High-Capacity Micro cellular PCS Systems," Proceedings of the IEEE-VTC-93, May 18-20, 1993, Secaucus, NJ.

12. K. Feher: "Wireless Digital Communications," forthcoming book Fall 1994 and publications. File ©KF, University of California, Davis, September 1992.

13 K. Feher, Ed. : " Advanced Digital Communications : Systems and Signal Processing Techniques." Prentic-Hall, Inc., Englewood Cliffs, New Jersey 07632, 1987.

14. J. McDonald, R. DeGroot, C. LaRosa : " Discussion of 0.39 GMSK Modulation for Frequency Hop Spreading Spectrum," a submission by Motorola. Submission to IEEE 802.11 Wireless Access Methods and Physical Layer Specifications, Doc. IEEE P802.11-93/79, May 1993.

15. N. Silberman : " Proposal for a modulation technique for frequency hopping spreading spectrum PHY standard," a submission by California Microwave, Inc., Doc. IEEE P802.11-93/94, May 10, 1993.

16. K. Feher : " Modems for Emerging Digital Cellular Mobile Radio Systems," IEEE Transactions on Vehicular Technology, Vol. 40, No. 2, May 1991.

17. S. Kato, K. Feher : " XPSK : A new cross-correlated phase-shift keying modulation technique," IEEE Transactions on Communications, May 1983.

18. N. Silberman, J. Boer : " Draft proposal for a frequency hopping and direct sequence spread spectrum PHY standard," Doc. IEEE P802.11-93/83rl, July 1993.

19. K. Feher : " 1 Mb/s and higher data rate PHY/MAC : GFSK and FQPSK," Doc. IEEE P802.11-93/138, September 1993.

20. K. Feher : "Flexible Higher (and Lower) Multiple Data Rate PHY/MAC Proposed Standard," Doc. IEEE P802.11-93/186, November, 1993.

21. S. Kato et al., NTT : " Preamble specifications for the standard 1 Mb/s FH-SS system and for higher speed systems," Doc. IEEE P802.11-93/189, November, 1993.

22. M. Soderstrand, et al., UC Davis : " DS-SS and Higher Speed FH-SS Modem VLSI Implementation ," Doc. IEEE P802.11-94/06, January, 1994.

23. N. Chayat, M. Rothenber (Lanniar, Israel) : " Simulation Results of Several WLAN Modulation Methods", Doc: IEEE P802.11-93/135.

24. N. Chayat (Lanniar, Israel) : " Consideration in FSK Tx Pulse Shaping and Rx Filtering for Low ISI at High Bit Rates," Doc. IEEE P802.11-93/160.

25. N. Silberman (Wireless-1) : "Modulation Selection Criteria," Doc. IEEE 802.11-93/164.

26. N. Silberman (Wireless-1) : "draft proposal for a Higher Data Rate Frequency Hopping Spread Spectrum PHY Standard," Doc. IEEE 802.11-93/210.

27. Z. Wan, et al., UC Davis : " Modulation Specifications for 2 Mb/s DS-SS System," Doc. IEEE P802.11-94/02, January, 1994.