IEEE P802.11

Wireless Access Methods and Physical Layer Specifications

TITLE: **Performance Study of Proposed GFSK and FQPSK Modulations for Wireless Standards**

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1. ABSTRACT

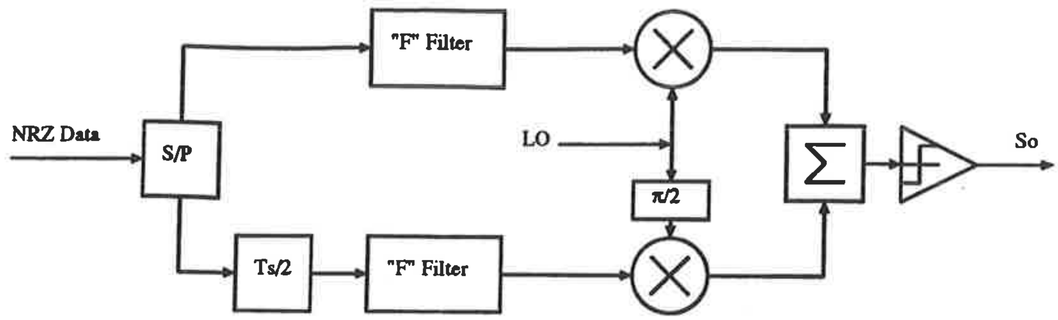
We present performance results of GFSK and compatible FQPSK studies. We compare the Power Spectral Densities (PSD) within IEEE 802.11 and FCC-15 specifications. We highlight the BER robustness and immunity to interference in environments dominated by Additive White Gausssian Noise (AWGN) and in Wirless mobile environments, and evaluate the impact of Delay Spread and Rayleigh Fade on BER.

Our results demonstrate that FQPSK outperforms GFSK (dev=160KHz) by 6.5dB Eb/No @ the IEEE 802.11 specified BER = 10^{-5} in AWGN, by about one order of magnitude in Delay Spread (eg. 150ns with Eb/No = 20dB as specified by IEEE 802.11), and by 5.5dB Eb/No in Rayleigh Fade.

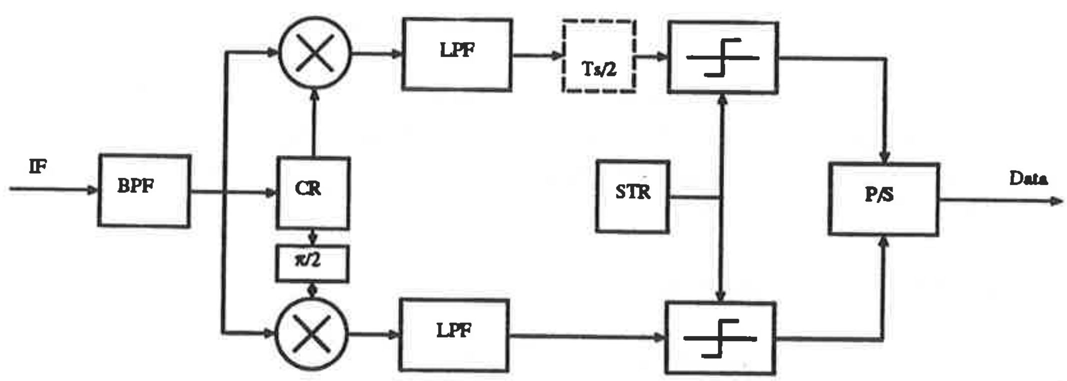
2. BASIS OF COMPARISON

For both systems, the data rate is 1Mb/s in 1MHz bandwidth.
For FQPSK, the normalized receive low pass filter bandwidth BTb = 0.55 (optimal for FQPSK).
For GFSK, BTb = 0.5, in line with the definition of GFSK.
The GFSK pre-detection and post-detection filters have been optimized. An Integrate-and-Dump filter has been assumed.
Both systems employ 4th order filters: Butterworth for FQPSK, Gaussian for GFSK.
For the Rayleigh Fade simulations, the American two-ray model has been used.
Doppler Spread = 1 Hz in Delay Spread and Rayleigh Fade analyses.

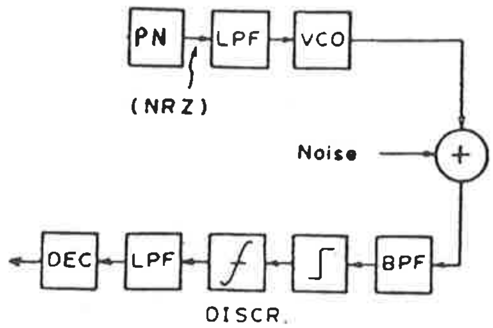
3. BLOCK DIAGRAMS OF Tx, Rx and Rayleigh Simulator



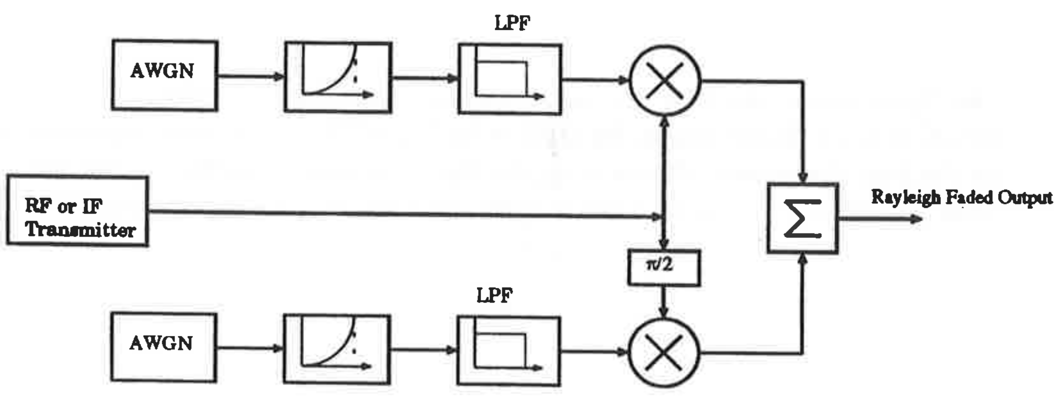
Block Diagram of FQPSK Modulator.



Block Diagram of Coherent Demodulator.

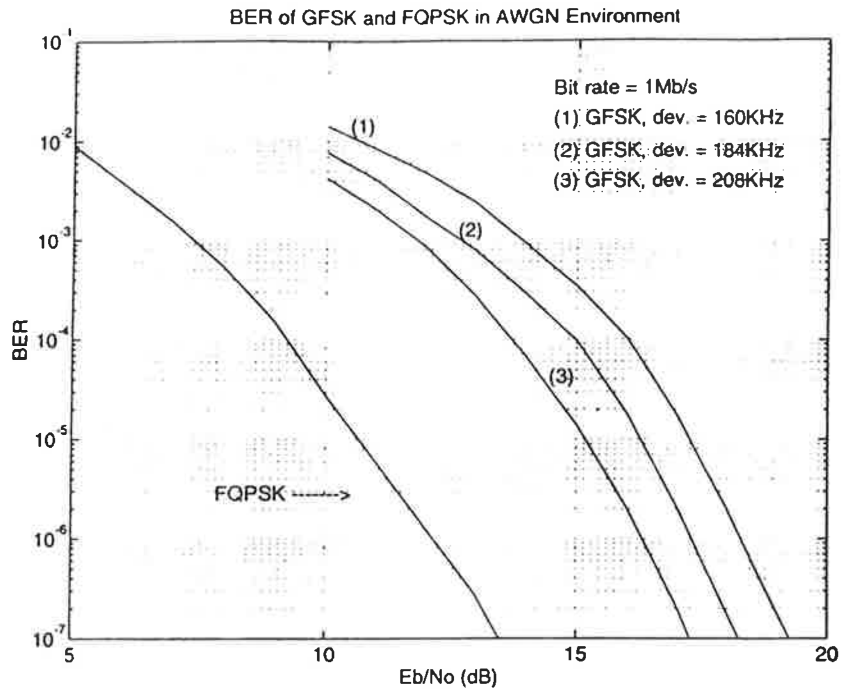


Block Diagram of GFSK modulator/demodulator

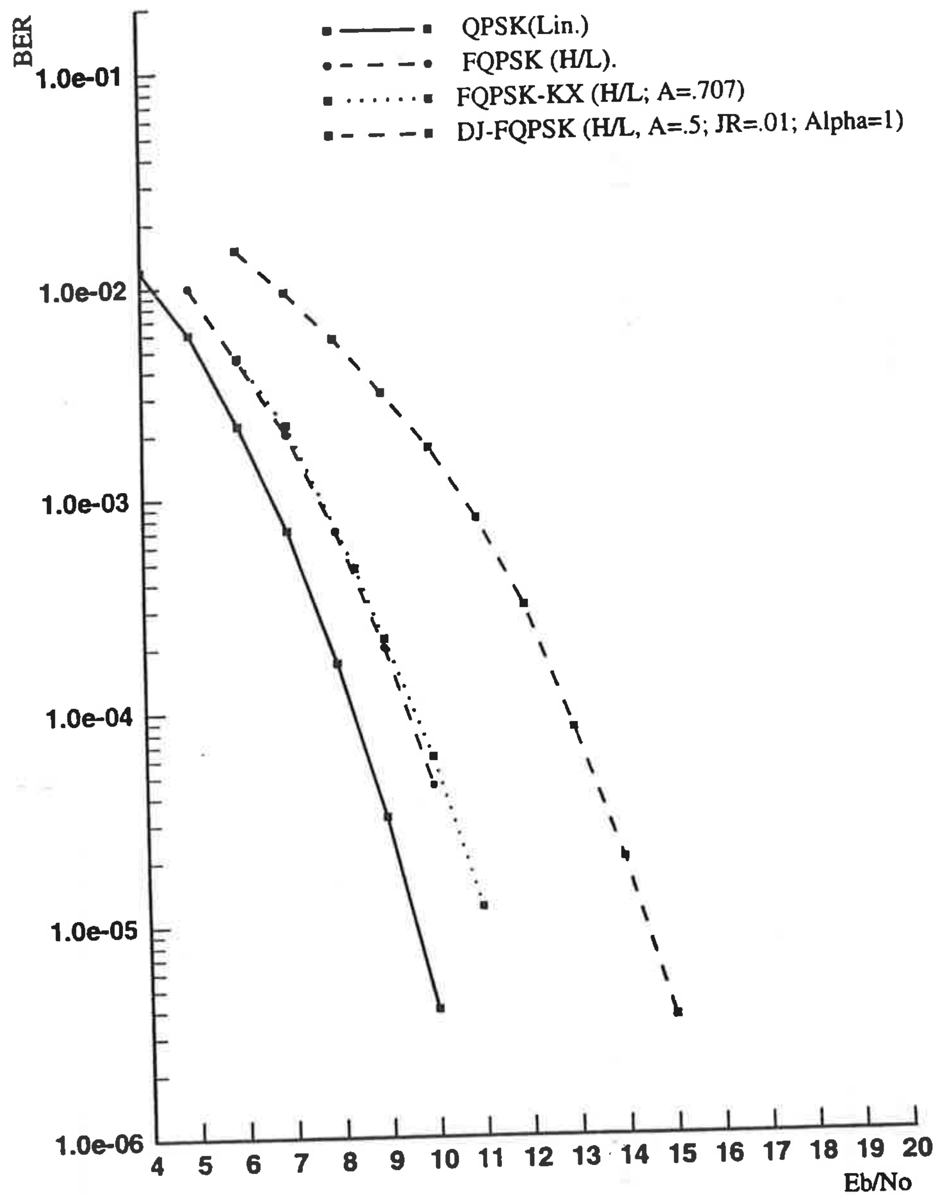


Block Diagram of Rayleigh Simulator.

4. BER COMPARISON IN AWGN ENVIRONMENT



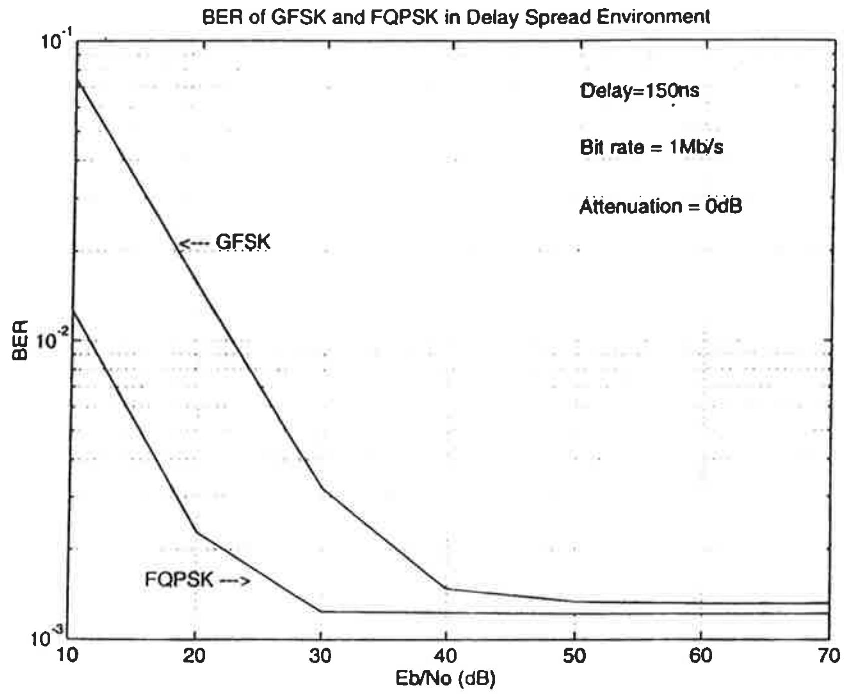
This figure shows that FQPSK requires approx. between 4-6.5 dB less Eb/No than the GFSK systems shown above, for BER = 10^{-5} in AWGN (the exact improvement depends on the freq. deviation). Alternatively, the figure demonstrates that for the same Eb/No, the BER of FQPSK is between 2 and 3 orders of magnitude better than the BER of GFSK.

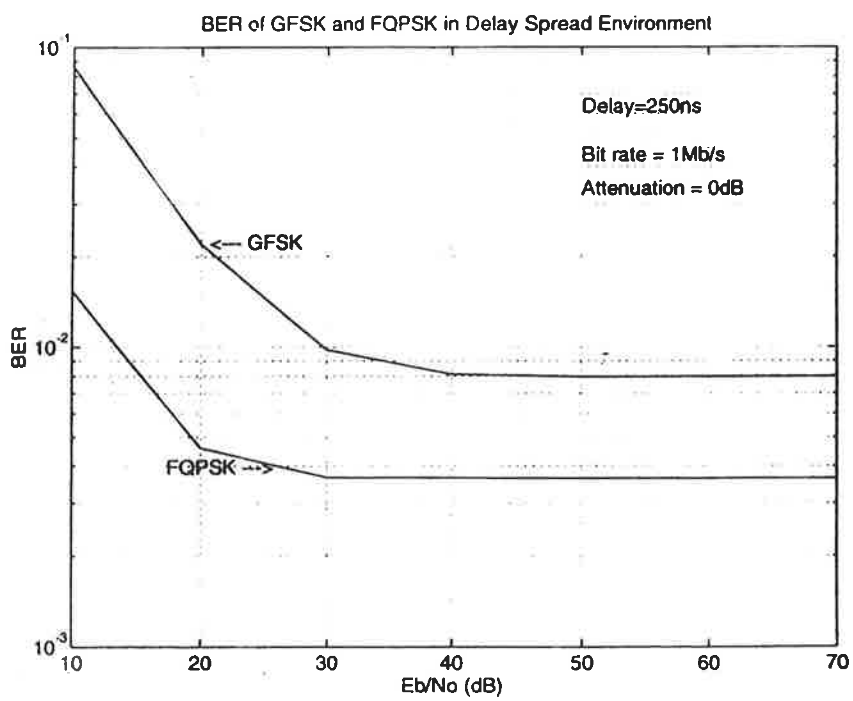


BER of FQPSK in AWGN. (Rx BPF: 4th order Butt. BTb=0.55)

The above results indicate that virtually all FQPSK systems, including the new FQPSK schemes proposed for higher data rates (such as FQPSK-KX and DJ-FQPSK) achieve very good BER performance (ref. [7] -[11]).

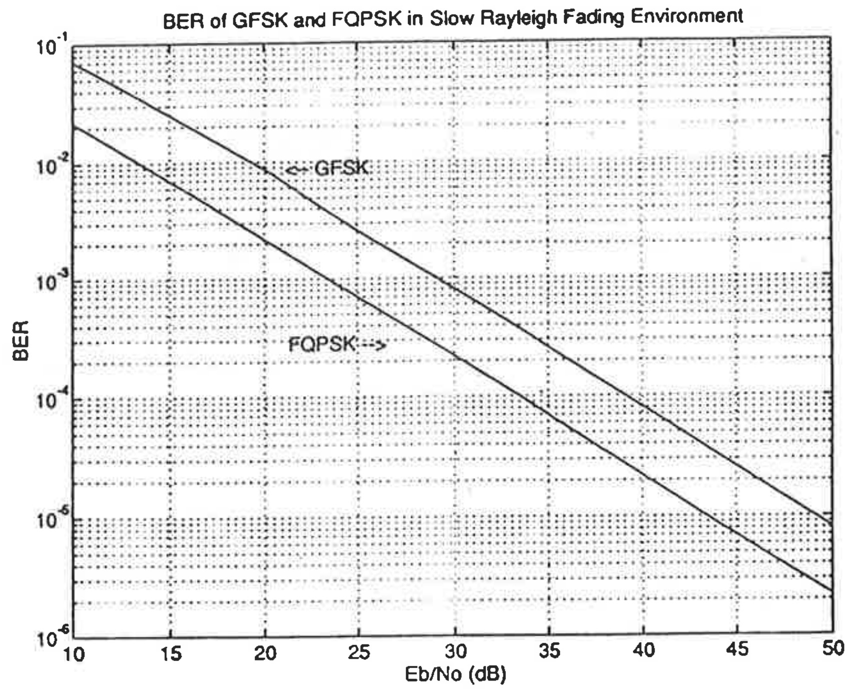
5. BER COMPARISON IN DELAY SPREAD ENVIRONMENT





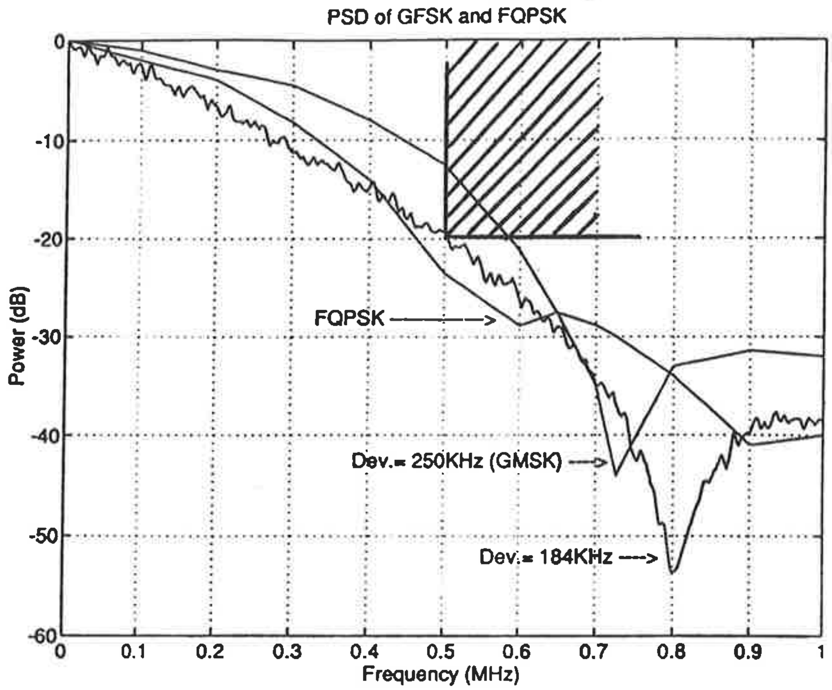
From the last two figures, we can clearly see the delay-spread robustness of FQPSK. For example, in the IEEE 802.11 specified 150ns delay with Eb/No = 20dB, BER of GFSK is as high as 1.5 10^{-2} while that of FQPSK is about one order of magnitude lower at 2.2 10^{-3}.

6. BER COMPARISON IN SLOW RAYLEIGH FADING ENVIRONMENT



In the figure above, the Doppler spread is 1Hz. GFSK with freq. deviation = 160 KHz is assumed.
The figure illustrates that FQPSK requires about 5.5 dB less Eb/No than this GFSK system, or that the BER of FQPSK is about 4 times better for the same Eb/No.

7. POWER SPECTRAL DENSITY COMPARISON



It is seen that among the modulation schemes analyzed above, FQPSK is the only one whose PSD does not violate the FCC requirement of -20dB attenuation at 0.5MHz. GFSK systems with dev < 184 KHz do meet this requirement; however, as we have shown earlier, the BER for a GFSK system with dev < 184 is considerably degraded when compared to FQPSK.

8. CONCLUSIONS

The prelinimary numerical results presented above quantify the superior spectral qualities and BER performance of FQPSK over GFSK in noise and interference polluted environments such as AWGN, Delay Spread and Rayleigh Fade. Hence, FQPSK should be preferred over GFSK in future Wireless Access Methods and Physical Layer Standardization Considerations.

Further data on the robustness of FQPSK are reported in 5 additional submissions to this meeting (references [7]-[11] below).

9. REFERENCES

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[11] PSK Leung: " Performance of FQPSK and Coherent QPSK Modulations in Indoor PCS Communications Environment With Time Delay Spread," IEEE 802.11-94/xx, March 1994.