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Performance of OQPSK and Equivalent FQPSK-KF for the DS-SS System

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Abstract

This paper proposes a configuration for the DS-SS System which employs Offset QPSK type modulation including GFSK and FQPSK modulation schemes. The proposed configuration requires very simple hardware and not much different from that of QPSK modulation systems. Moreover, this paper shows some experimental results on the performances of Offset QPSK DS-SS systems in nonlinear channel.

1 Introduction

In Wireless Local Area Networks Communications, spectral efficiency is one of the most important parameters to specify the systems in addition to the cost of the system. Along with this purpose, a family of off-set QPSK modulation, FQPSK, FQPSK-KF have been proposed (1)-(4) and discussed assuming not expensive hardware implementation of the modem. These offset QPSK type modulation schemes have better spectrum efficiency in nonlinear channels and make it possible to employ power amplifiers at saturation level.
Although the offset QPSK modulation scheme has been studied and employed in several DS-SS systems such as Qualcomm's CDMA system(5),(6), it is worth to seek simple hardware to solve unnecessary doubtness on OQPSK DS-SS system realization.

There are various methods to realize DS-SS systems employing offset QPSK modulation. The choices at the modulation are (1) BPSK or QPSK modulation before spreading, (2) 0.5 Tc or 5.5 Tc offset. At the demodulator, the choices are (1) despreading at IF stage or baseband, (2) QPSK or OQPSK demodulators.

This paper choose QPSK modulation before spreading due to odd number of Barker sequence adopted for DS-SS systems. The chip offset of 0.5 Tc or 5.5 Tc will be selected coupled with a QPSK or OQPSK demodulator after spreading. For hardware implementation simplicity, baseband despreading has been adopted.

2. Configuration of Offset QPSK type Spread Spectrum Modem

The operation of the Offset QPSK type Spread Spectrum[(5)(6)] Modem (Offset QPSK type Spread Spectrum and QPSK original data) is explained as follows.

The information signals I(t) and Q(t) are spreaded by spreading code Si and Sq, respectively at in-phase and quadri-phase channels. The spreaded baseband signals **I(t)** and **Q(t)** are ;

$$\mathbf{I(t)} = I(t)\ Si$$

$$\mathbf{Q(t)} = Q(t)\ Sq$$

The symbol duration is Ts and the chip duration is defined as Tc. Here, the information bit rate is 2 Mbps

$$1/Ts = 1\ (MHz)$$

$$1/Tc = 11\ (MHz)$$

$$Ts = 11\ Tc$$

Then, the quadri-phase signal fin**Q(t)** is delayed by Tc/2 (or 11Tc/2). The offset quadri-phase signal is deed as **Q'(t)**.

The transmitted signal generated by the orthogonal modulator, **T(t)** is given as follows.

$$\mathbf{T(t)} = \mathbf{I(t)} + j\mathbf{Q'(t)}$$

At the demodulator, the received signals is converted 0-IF signal, then they are de-spreaded by the spreading code Si and S'q by the matched filter (or DLL : Delay Lock Loop). The de-spreaded signals RI(t) and RQ(t) are :

$$\begin{aligned} RI(t) &= \mathbf{T(t)}\ Si \\ &= (\mathbf{I(t)} + j\mathbf{Q'(t)})\ Si \\ &= (I(t)\ Si + jQ'(t)\ S'q)\ Si \\ &= I(t) + jQ'(t)\ S'q\ Si \end{aligned}$$

$$\begin{aligned} RQ(t) &= -j\mathbf{T(t)}\ S'q \\ &= -j(\mathbf{I(t)} + j\mathbf{Q'(t)})\ S'q \\ &= (-jI(t)\ Si + Q'(t)\ S'q)\ S'q \\ &= -jI(t)\ Si\ S'q + Q'(t) \end{aligned}$$

The de-spreaded signals RI(t) and RQ(t) are fed to the orthogonal demodulator, and the original data, I(t) and Q(t) are demodulated, respectively.

3. Experimental Results

The hardware experiments have been carried out on the bit error rate performances in additive white Gaussian noise environments and power spectral efficiency of OQPSK signals in the DS-SS system to transmit 2Mbit/s signal with a spreading code of 11 bit (Baker sequence; 1, -1, 1, 1, -1, 1, 1, 1, -1, -1, -1). The spreaded and offset QPSK modulated signals are transmitted over linear and nonlinear channels then demodulated coherently. The bit error rate performance of the OQPSK DS-SS signals in linear and nonlinear channels are shown in Fig.2 and Fig.3. The bit error performance in nonlinear channels degrades about 0.5 dB from that in linear channels due to inter-symbol interference but this will not affect bit error rate performance in Rayleigh fading channels.

The power spectrum after passing through a non linearly amplified power amplifier is shown in Fig.4(a). That of QPSK signals is also shown in Fig.4(b) for comparison. As seen from these figures, OQPSK modulated signals achieve about 7dB lower first sidelobe level and this difference leads to use of the power amplifier at the near saturation level.

In the case of FQPSK, a kind of OQPSK modulation and achieving constant envelope characteristics, the bit error rate is almost the same to that shown in Fig.2 and 3, the power spectrum is more compact and makes it possible to use the power amplifier at the saturation level.

4. Conclusion

This paper has proposed a simple hardware implementation of the DS-SS system employing OQPSK modulation. Moreover, hardware experimental results on the bit error rate and power spectrum of the above mentioned system show the feasibility of the DS-SS system employing OQPSK type modulation schemes such as FQPSK-KF modulation.

References

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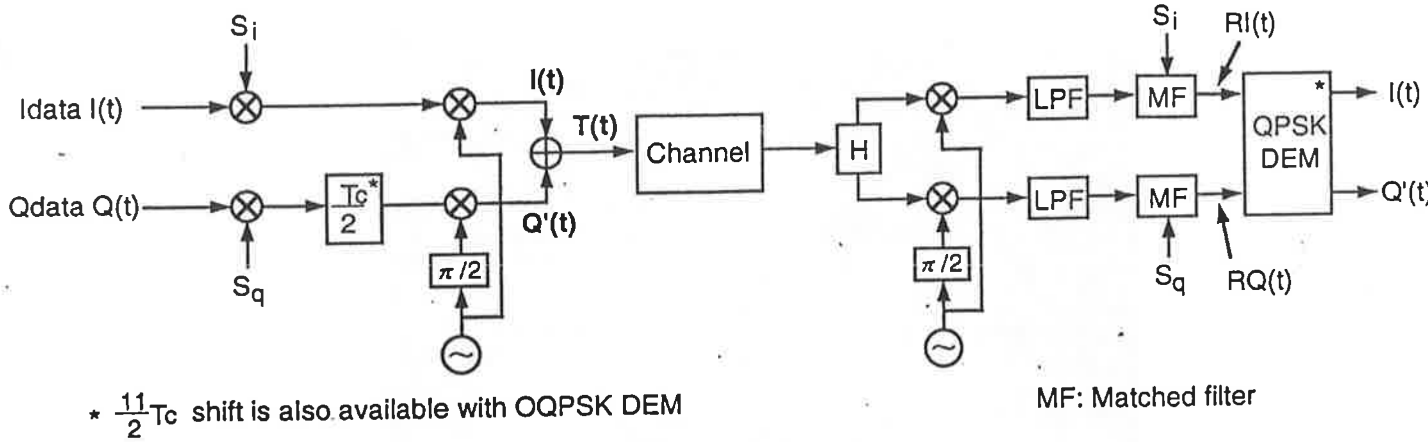


Fig.1 Configuration of OQPSK type SS modem

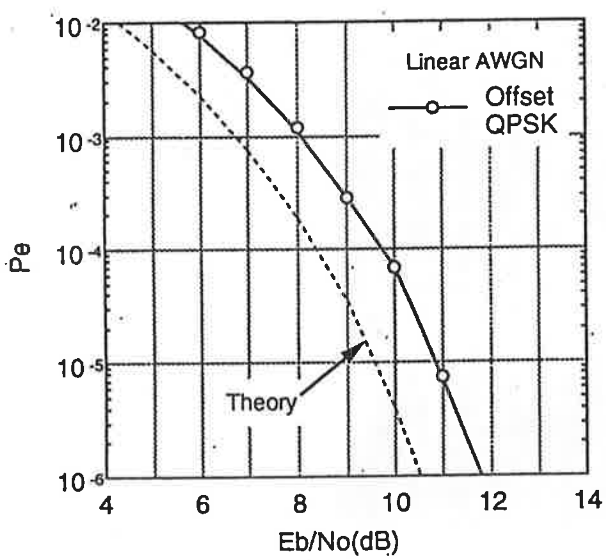


Fig.2 Pe performance of Offset QPSK-CDMA (Linear)

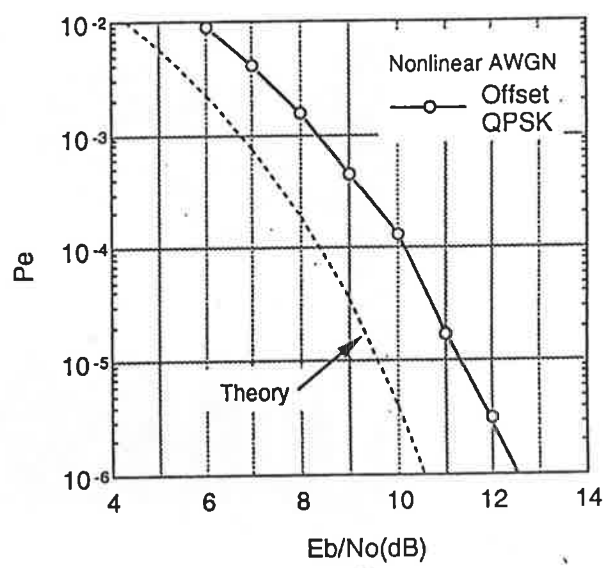
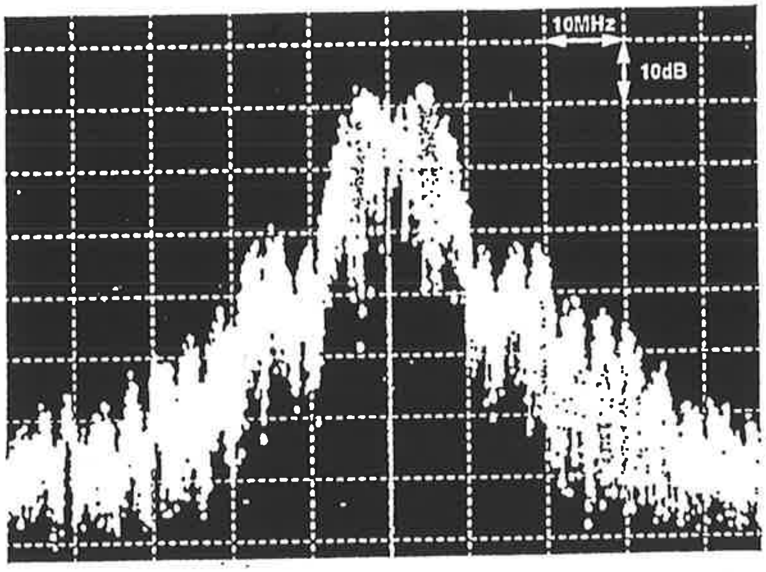
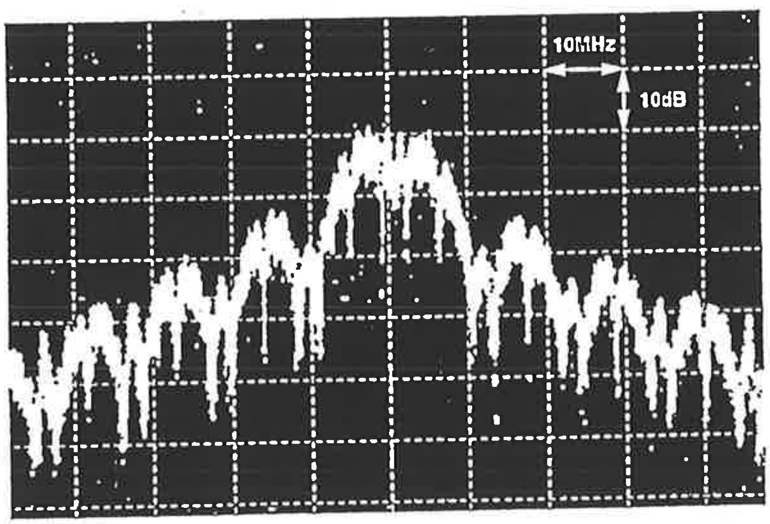


Fig.3 Pe performance of Offset QPSK-CDMA (Nonlinear)



(a) Nonlinear OQPSK



(b) Nonlinear QPSK

Fig.4 Power spectra.