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Wireless Multimedia Communications

Networking Video, Voice, and Data

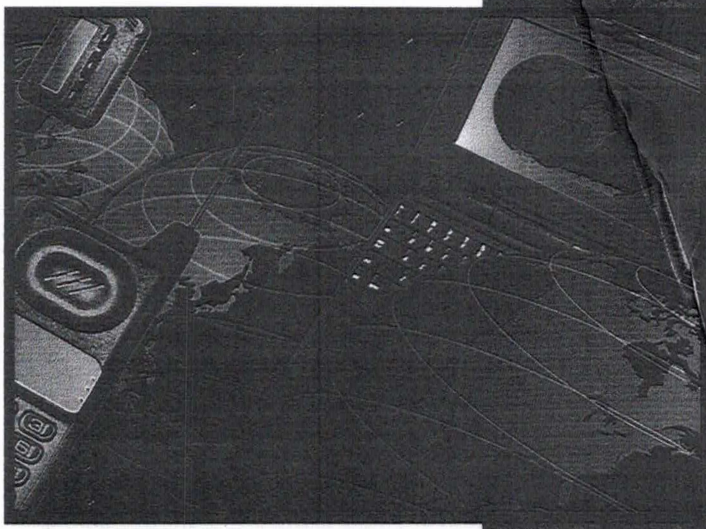

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Figure 3.22 shows the traditional performance superiority of ideal PSK over FSK. For example, a system that coherently detects a PSK signal can achieve a BER under 10^{-5} for an E_b/N_o of 10 dB, whereas a system that coherently detects an FSK signal achieves only a BER of 10^{-3} for an E_b/N_o of 10 dB.

Noncoherent detection, such as differential and discriminator detection, has received some attention [Korn85]. Carrier phase recovery and symbol time extraction can be challenging for CPM schemes, especially after the ISI introduced by filtering and the radio channel.

Several researchers [Miyakawa75, Anderson78, Aulin82] have studied more spectrally efficient schemes, including multi-*h* phase coding, where the modulation index is time-varying, typically cyclically. Convolutional coding is often added to reduce the BER [Pizzi85]. For example, rate 2/3 convolutional codes combined with 8-level CPM yield performance improvements over uncoded 4-level CPM at the price of increased complexity. Applications of CPM to radio environments can be found in [Murota81, Murota81a, Chung84, Maseng85, Ekemark85, Asakawa81, Sundberg83].

3.4 Multicarrier Modulation (MCM)

Multicarrier modulation (MCM), also called orthogonal frequency division multiplexing (OFDM), is described in detail in Section 5.2, since one of its main attractions

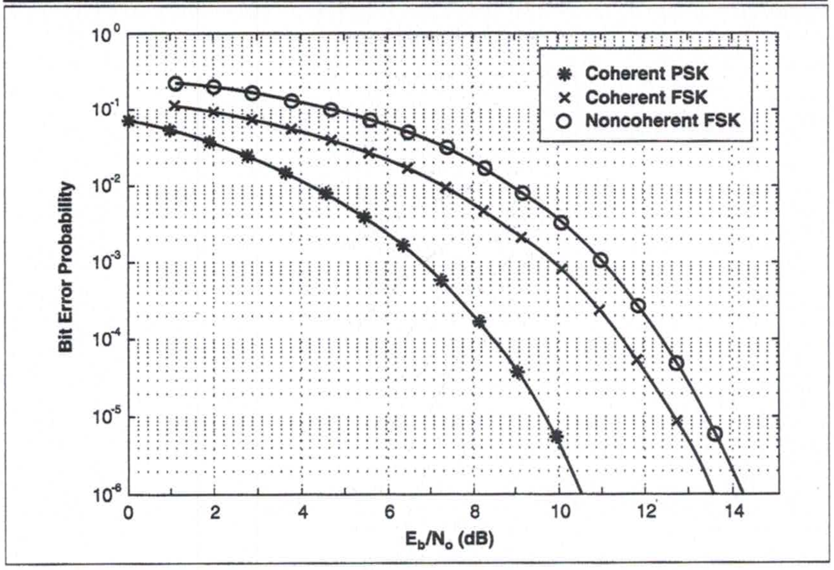

Figure 3.22 Comparing BPSK performance with coherently detected and noncoherently detected FSK.

is its ISI-mitigation properties. We define it here briefly to complete our study of modulation schemes.

MCM is a form of frequency division multiplexing (FDM), where the bits in a packet are transmitted in parallel, each at a low bit rate [Bingham90]. The European digital audio broadcast (DAB) standard uses MCM, which allows digital broadcasting to be added to analog AM and FM broadcasting [Wilson]. The low bit rate subchannels are each more resilient against frequency-selective fading in time than is one high-bit rate wideband transmission. Frequency-selective fading causes some subchannels to have extremely poor performance. However, coding across subchannels resolves this issue.

The MCM signal is generated using digital signal processing (DSP) techniques at baseband; it then modulates an RF carrier. MCM uses frequency division multiplexing with subcarrier frequencies spaced at the symbol rate. If the packet duration is T, and the number of tones is N, the subcarrier frequencies are at $1/T$, $2/T$, $3/T$, . . . N/T. This frequency spacing makes the subcarriers orthogonal over one symbol interval. The transmitter transmits individual channels at $1/N$ of the aggregate rate. We can efficiently implement an MCM modulator using an inverse discrete Fourier transform (DFT) to convert the complex phase/amplitude data for each subcarrier into a sampled MCM signal. At the receiver, we can demodulate the signal with a DFT.

As seen in Figure 3.23, the MCM modulator collects a block of bits from the data source, encodes them into complex quadrature amplitude modulation (QAM) data values, and converts the data to signal samples using an inverse FFT. The digital-to-

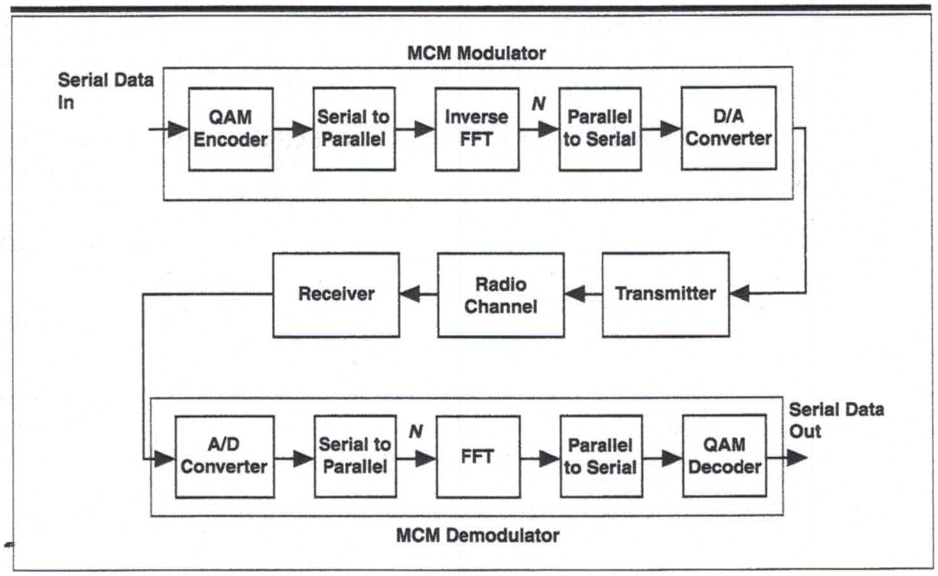

Figure 3.23 Possible multicarrier modulation (MCM) implementation.

analog converter (DAC) produces the analog baseband OFDM signal. This baseband signal modulates an RF transmitter. The modulated signal is transmitted over the fading channel. The demodulator at the receiver collects a block of samples from the analog to digital converter, converts the samples to complex values using an FFT, and decodes the complex values back to bits.

3.5 Conclusions

We must consider many issues in choosing a modulation scheme for transmission over a radio medium, including spectrum efficiency, power consumption, bit error rate performance, robustness to interference both intersymbol and cochannel, and implementation complexity. Traditionally, QPSK has been favored over BPSK because it occupies half the spectrum. Several U.S. radio communications standards, including IEEE's 802.11 standard for wireless LANs, use QPSK. Many recent European radio communications systems, such as DECT, GSM, and HIPERLAN have been implemented using GMSK because of that modulation's comparatively narrow spectrum, low error rates in the presence of fades, and constant envelope property. Multicarrier modulation enjoys ISI-mitigation properties that make it especially suitable for high data rate transmission. We will explore it again in Chapter 5. The error performance of all of these schemes can be improved with the use of diversity (Chapter 4), ISI mitigation (Chapter 5), and coding (Chapter 6).

3.6 References

[Amoroso77] F. Amoroso and J.A. Kivett. "Simplified MSK Signaling Technique," *IEEE Transactions on Communications*, Vol. COM-25, No. 4. April 1977.

[Anderson78] J.B. Anderson and D.P. Taylor. "A Bandwidth-Efficient Class of Signal Space Codes," *IEEE Transactions on Information Theory*, Vol. IT-24, No. 6, pp. 703–712. November 1978.

[Anderson86] J.B. Anderson, T. Aulin, and C-E Sundberg. *Digital Phase Modulation*. Plenum Press, 1986. [030642195X]

[Anderson91] B. Anderson and C-E.W. Sundberg. "Advances in Constant Envelope Modulation," *IEEE Communications Magazine*. December 1991.

[Ariya92] S. Ariyavisitakul. "Equalization of Hard-Limited Slowly-Fading Multipath Signal Using a Phase Equalizer with Time-Reversal Structure," *IEEE Journal on Selected Areas in Communications*, Vol. 10, No. 3, pp. 589–598, April 1992.

[Asakawa81] S. Asakawa and F. Sugiyama. "A Compact Spectrum Constant Envelope Digital Phase Modulation," *IEEE Transactions on Vehicular Technology*, Vol. VT-30, No. 3, pp. 102–111. August 1981.