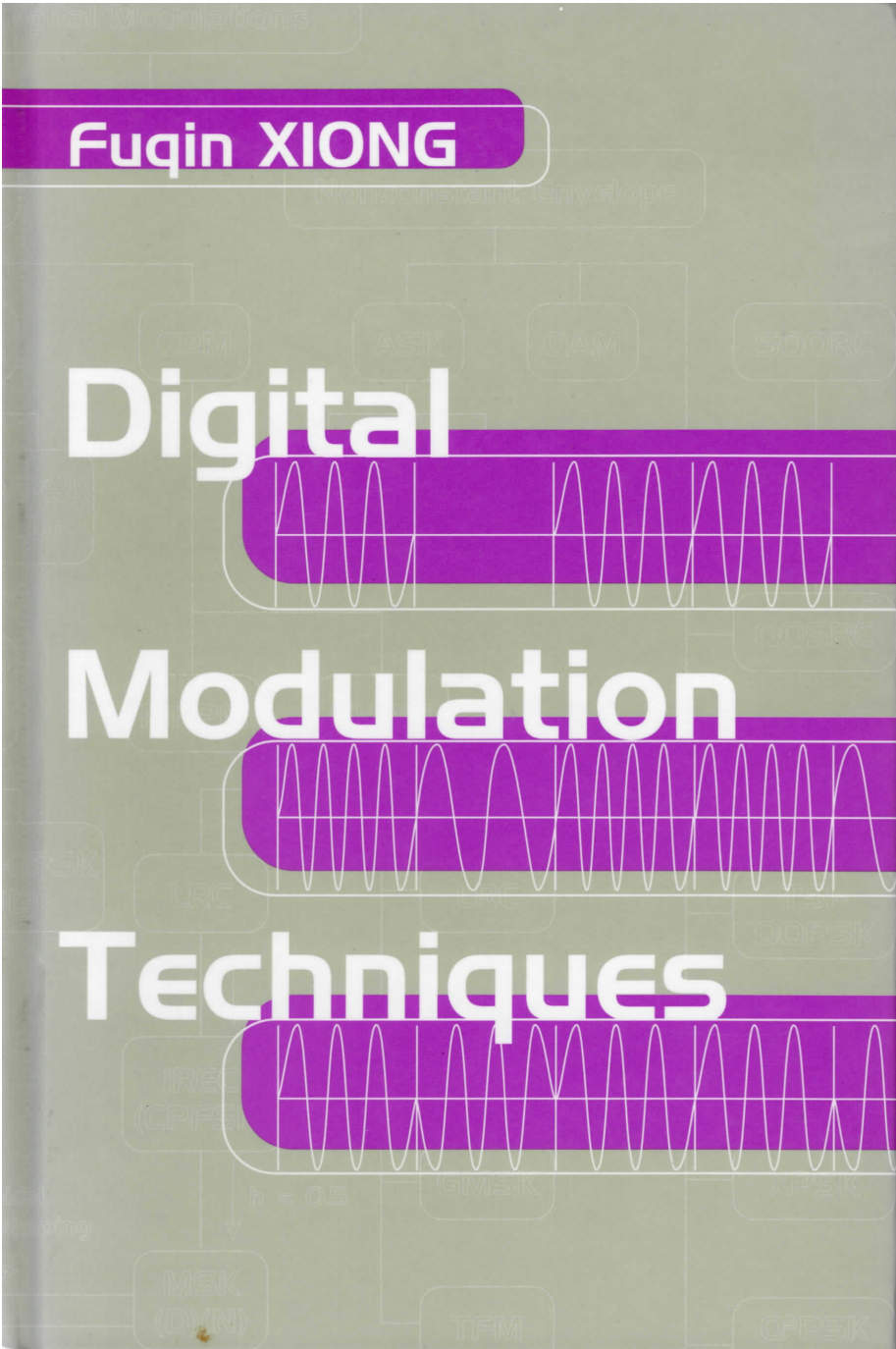


Fuqin XIONG

Digital Modulation Techniques

The background of the cover is a light gray with a faint, repeating pattern of various digital modulation techniques in rounded rectangular boxes. These include: PSK, ASK, QAM, BPSK, QPSK, LRC, BPSK, QPSK, IRSA (CPFSK), h = 0.5, QPSK, XPSK, MSK (DM), and TFM. Overlaid on this pattern are three horizontal purple bars. Each bar contains a white waveform: the top bar shows a high-frequency sine wave, the middle bar shows a lower-frequency sine wave, and the bottom bar shows a complex waveform with varying amplitudes.

Digital Modulation Techniques

Fuqin Xiong



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base station receiver. By using multiple base station antennas, the base station receiver can choose the strongest signal from the mobile.

2. *Polarization diversity.* A scattering environment tends to depolarize a signal. Receiver antennas having different polarizations can be used to obtain diversity. An example is the use of vertical monopole and patch antennas in cellular telephone user units. Another application of polarization diversity is at the base station. At base station space diversity is less practical because the narrow angle of incident fields requires large antenna separation. However, orthogonal polarization diversity is possible since many users are using portable units and the signal polarizations are no longer pure vertical due to hand-tilting.
3. *Frequency diversity.* This is achieved by transmitting the same signal on multiple carriers. These carrier frequencies are separated by at least the coherent bandwidth of the channel. Thus each signal does not experience the same fading. Frequency diversity is often used in microwave line-of-sight links using frequency division multiplexing (FDM). In these links deep fading may occur due to tropospheric propagation and resulting refraction. A spare frequency channel is usually provided for several frequency channels, each carrying an independent traffic. If any one of the frequency channels is experiencing deep fading, its traffic can be switched to the spare channel.
4. *Time diversity.* Signals are transmitted in multiple time slots separated by at least the coherence time of the channel. For example, repetition codes transmit a symbol in several time slots. Other sophisticated error control codes encode a message sequence into a longer coded sequence. This is also a type of time diversity because the information is distributed on the entire code so if a part of it is erased the information can still be recovered. Interleaving is usually used in combination with error control codes. When an interleaved sequence is deinterleaved at the receiver, bursty errors are spread out and become isolated errors which can be easily corrected by the error control code. Interleaving effectively separates the symbols corresponding to a message by more than the channel coherence time.
5. *Multipath diversity.* Using a tapped delay line the energy in the multipath components can be collected and their weighted sum becomes a stronger signal. This type of receiver is called a RAKE receiver since the block diagram is just like a garden rake. Multipath diversity is also sometimes considered as time diversity since signal components at different times are collected.

There are also other diversity techniques. The *angle diversity* or *direction diversity* uses several directional antennas. Each antenna receives plane waves arriving from a narrow range of angles. Signals received by different antennas are thus uncorrelated. A new technique is called *diversity transform* [28] which transforms the