Orthogonal frequency-division multiplexing (OFDM) is a very attractive transmission technique for future high data rate wireless multimedia communication systems. OFDM has been developed for wideband wireless digital communication and is used in applications such as Digital Video and Audio Broadcasting (DVB, DAB, respectively), wireless networking and broadband Internet access [1]-[3].

OFDM has advantages, such as high spectral efficiency, easy adaptation to severe channel conditions without complex equalization, and efficient implementation using fast Fourier transform (FFT). However, it also has some disadvantages, such as sensitivity to frequency offset, a high peak-to-average-power ratio (PAPR) and sensitivity to noises [1], [4], [5].

As discussed in Chapter 3, OFDM is successfully used in MIMO systems. This chapter is devoted to investigate the various RF impairments, specifically noise and nonlinearity, and their mutual impacts on OFDM transceivers.

8.1 OFDM Transceivers

Orthogonal frequency-division multiplexing is a frequency-division multiplexing (FDM) scheme utilized as a digital multicarrier modulation method. A large number of closely spaced orthogonal subcarriers are used to carry data, which are divided into several parallel data streams or channels, one for each subcarrier. Each sub-carrier is modulated with a conventional modulation scheme, such as quadrature amplitude modulation (QAM) or phase-shift keying (PSK) at lower symbol rates, maintaining total data rates similar to conventional single-carrier modulation schemes in the same bandwidth [2], [20]. Figure 8.1 shows a block diagram of an OFDM transceiver system.

The input data is first de-multiplexed into \( N \) parallel streams, and each one is mapped to a (possibly complex) symbol stream using some modulation constellation (QAM, PSK, etc.). An inverse FFT is computed on each set of symbols, giving a set of complex time-domain samples. These samples are then quadrature-mixed to passband in the standard way. The real and imaginary components are first converted to the analog domain using digital-to-analog converters (DACs); and, the analog signals are then used to modulate cosine (real) and sine (imaginary) waves at the carrier frequency, \( f_c \). These signals are then summed to give the transmission signal, \( S(t) \).
The receiver picks up the signal, \( r(t) \), which is then quadrature-mixed down to baseband using cosine and sine waves at the carrier frequency. This also creates signals centered on \( 2f_c \), so low-pass filters are used to reject these. The baseband signals are then sampled and digitized using analog-to-digital converters (ADCs), and a forward FFT is used to convert back to the frequency domain. This returns \( N \) parallel streams, each of which is converted to a binary stream using an appropriate symbol detector. These streams are then re-combined into a serial stream, which is an estimate of the original binary stream at the transmitter [1], [20].

### 8.2 Noise in OFDM Transceivers

It is very important to exactly predict and analyze the oscillator noise influences in OFDM communication systems and quantify the tolerable level of noise. Phase noise effects in OFDM have been analyzed in many papers by several authors [4], [5], [7]-[19]. However the effect of amplitude noise was not considered and always ignored relative to phase noise. In this section, the theoretical analysis of the impact of the oscillator phase and amplitude noise on the signal-to-noise ratio (SNR) and, hence, the bit error rate (BER) performance of MQAM-OFDM signals over an additive white Gaussian noise (AWGN) channel are presented; and, the tolerable levels of phase and amplitude noise are extracted.