ORTHOGONAL FREQUENCY DIVISION MULTIPLEX (OFDM)

ECE2526E – MOBILE SYSTEMS

Monday, 07 April 2025

WHAT IS OFDM?

1. OFDM is a digital modulation scheme where higher data streams are split into a number of lower data streams simultaneously and used to modulate multiple subcarriers.
2. The data stream is split into N parallel streams of reduced data rate and transmit each on a separate subcarrier.
3. When the subcarriers have appropriate spacing to satisfy orthogonality, their spectra can overlap without causing interference.
4. OFDM uses digital signal processing (DSP) techniques based on FFT and IFFT.

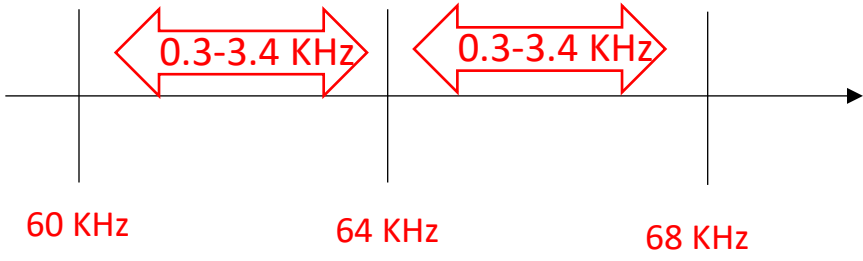
WHAT IS ORTHOGONALITY?

1. If the integral of the product of two signals is zero over a time period, then these two signals are said to be orthogonal to each other.

2. Two sinusoids with frequencies that are integer multiples of a common frequency can satisfy this criterion.

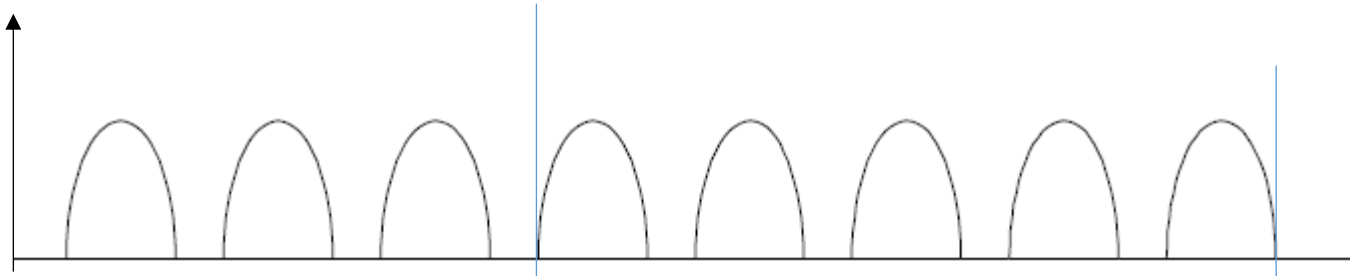
$$\int_0^T \cos(2\pi n f_o t)\cos(2\pi m f_o t) = 0 \qquad for\ n \neq m$$

OFDM LEADS TO BANDWIDTH EFFICIENCY



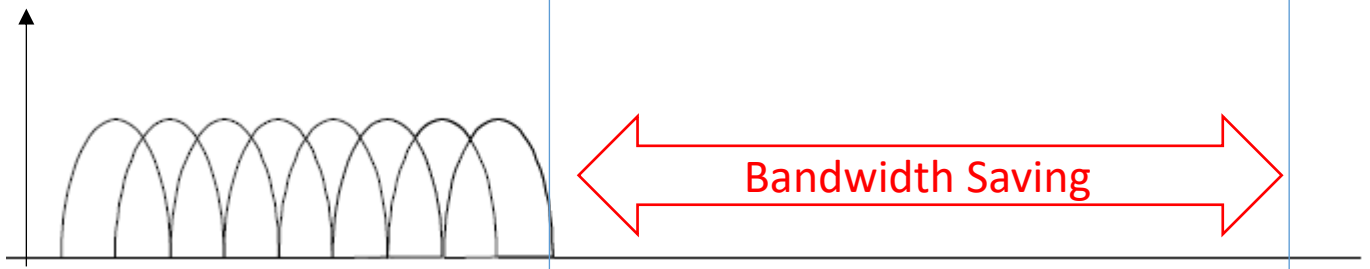
Example: Analogue Telephone FDM

FDM



Frequency

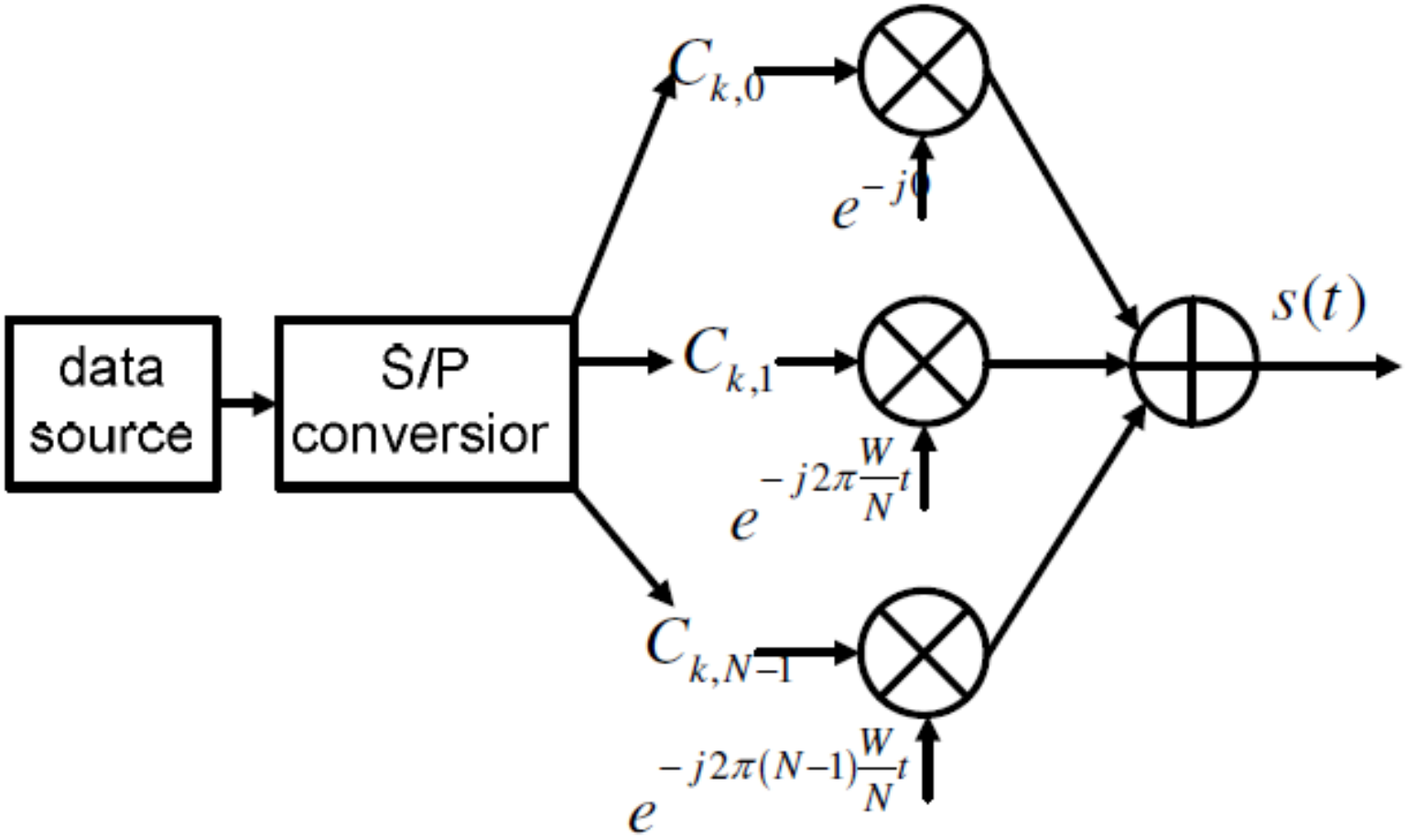
OFDM



Frequency

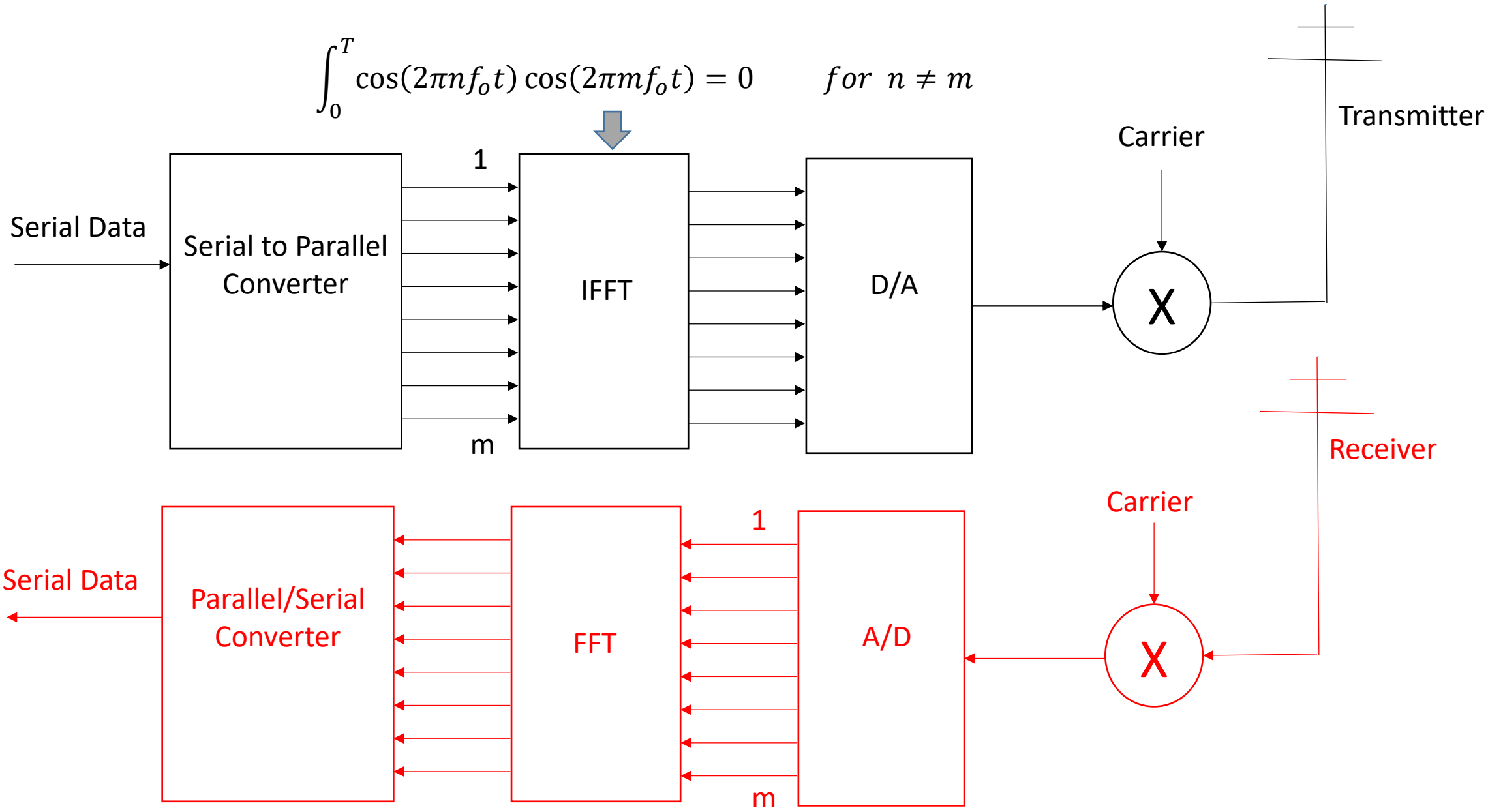
GENERATION OF OFDM SIGNALS

$$\int_0^T \cos(2\pi n f_o t)\cos(2\pi m f_o t) = 0 \qquad for\ \ n \neq m$$

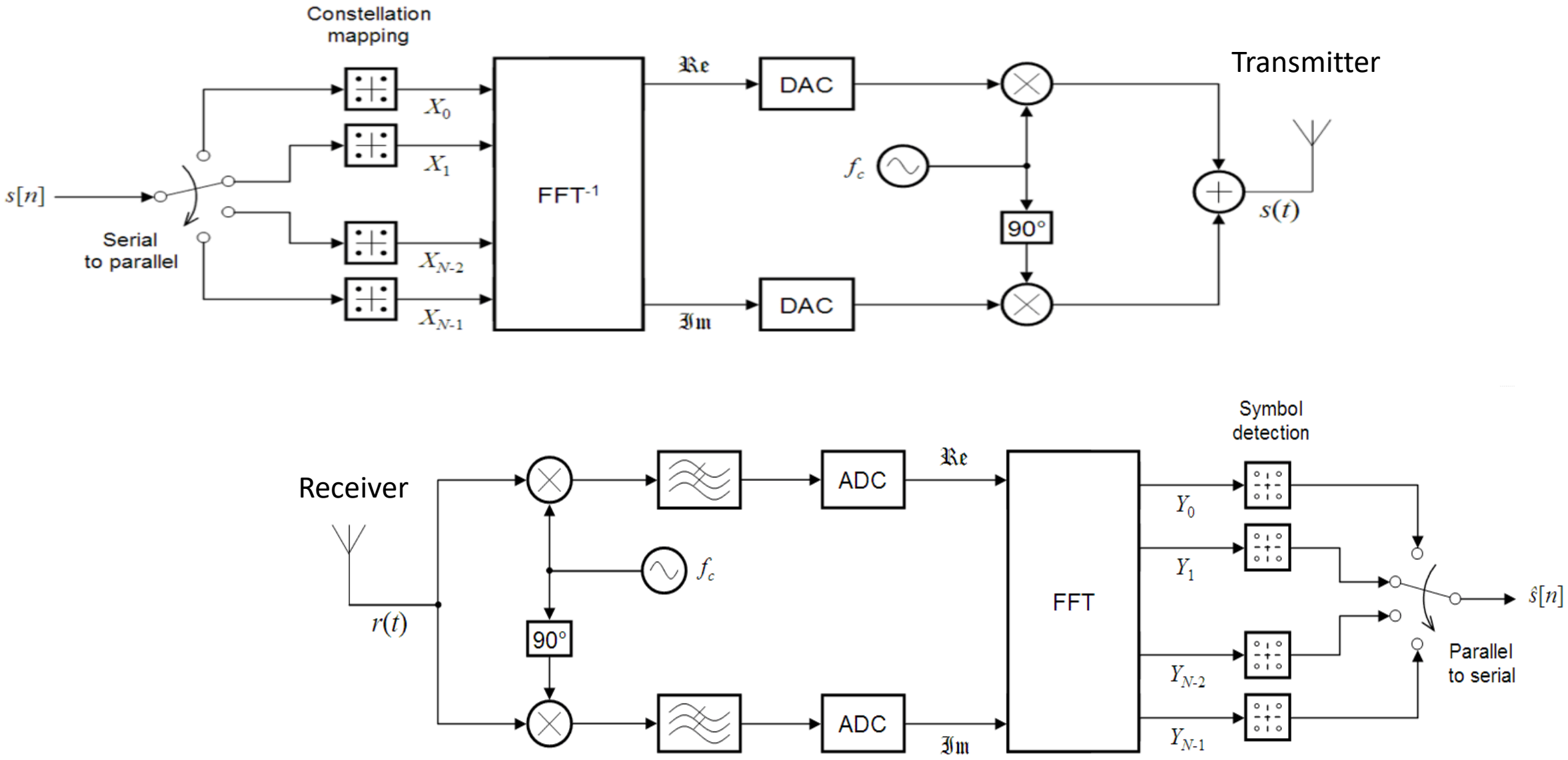


OFDM IMPLEMENTATION USING FFTs

$$\int_0^T \cos(2\pi n f_o t)\cos(2\pi m f_o t) = 0 \qquad for\ \ n \neq m$$



OFDM USING QAM

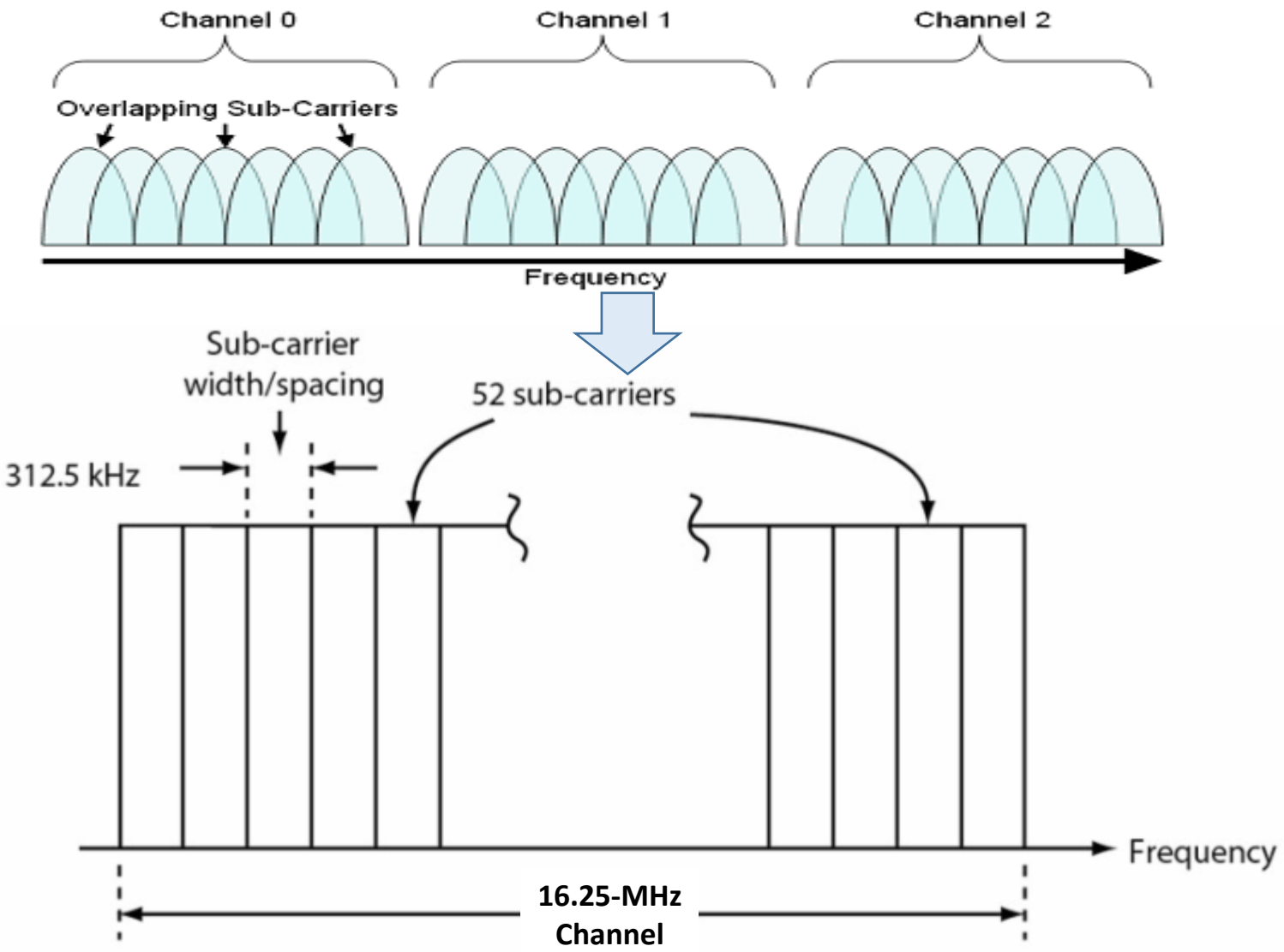


APPLICATIONS OF OFDM - LTE

1. LTE defines a number of channel bandwidths to provide flexibility as follows:
   a) 1.4 MHz
   b) 3 MHz
   c) 5 MHz
   d) 10 MHz
   e) 15 MHz
   f) 20 MHz
2. **Each channel is identified by a number commonly referred to as Evolved Absolute Radio Frequency Channel Number (EARFCN)**
3. The subcarriers spacing is 15 kHz, i.e. the LTE subcarriers are spaced 15 kHz apart from each other, i.e a symbol rate of 1 / 15 kHz = of 66.7 µs.
4. Peak upload rates of 75.4 Mbit/s for a 20 MHz channel
5. Peak download rates of 299.6 Mbit/s for 4×4 antennas, and 150.8 Mbit/s for 2×2 MIMO antennas for a 20 MHz channel

APPLICATIONS OF OFDM - WiFi

1. Each WiFi channel occupies 16.25 MHz of bandwidth at the 2.4GHz frequency range.
2. Each channel is divided into 52 sub-carriers of 312.5 kHz.
3. These sub-carriers overlap to fully utilize the 16.25MHz channel bandwidth dedicated per channel.
4. WiFI can use BPS, QPSK, 16-QAM, or 64-QAM depending on the characteristics of the physical channel.



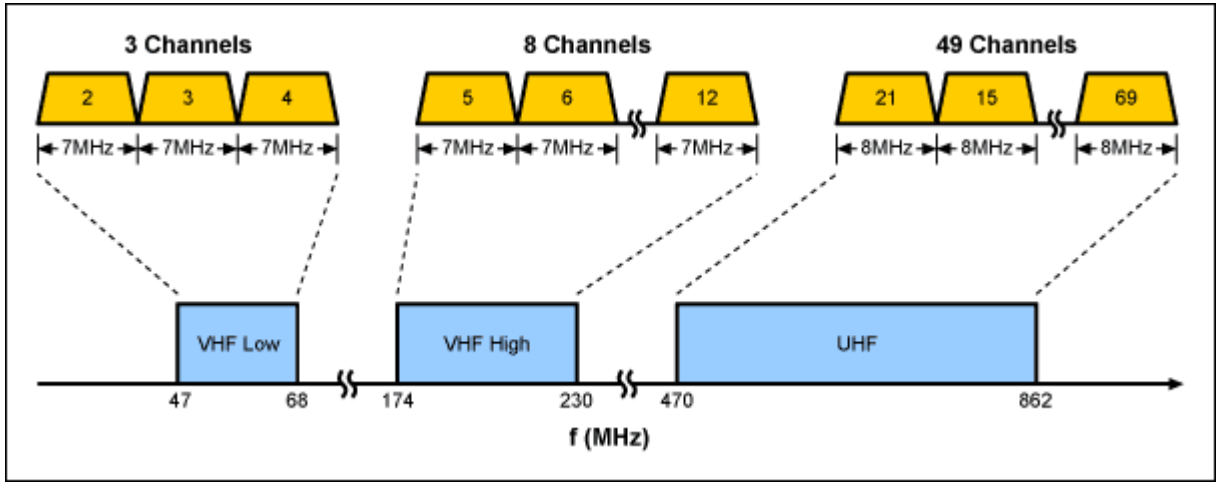
APPLICATIONS OF OFDM – DVB-T

1. **Digital Video Broadcasting - Terrestrial (DVB-T):** is an international standard for the broadcast transmission of digital terrestrial television that was first published in 1997.

2. **DVB-T transmits compressed digital audio, digital video and other data in an MPEG transport stream, using coded orthogonal frequency-division multiplexing.**

3. Rather than carrying one data carrier on a single radio frequency (RF) channel, **DVB-T splits the digital data stream into a large number of slower digital streams, each of which digitally modulates a set of closely spaced adjacent sub-carrier frequencies**.

4. **DVB-T can operate on three different modulation schemes, i.e QPSK, 16QAM, 64QAM.**



APPLICATIONS OF OFDM - WiMax

1. **WiMax (or IEEE 802.16) is** an internet communications protocol specifically designed to provide internet access across long wireless links of up to 50 kms.
2. **WiMAX can have data throughputs of up to 75 Mbps and operates globally in the 2.5 GHz, 3.5GHz, and 5.8 GHz bands.**
3. **Each WiMax OFDM channel consists of 128 to 2048 sub-carriers.**
4. Each WiMax OFDM channel can occupy bandwidths from 1.25 MHz to 20 MHz.
5. **Each WiMAX sub-carrier can be modulated using BPSK, QPSK, 16-QAM, or 64-QAM** modulation, depending on the requirements of the physical channel.