

# RF Basics

# Basic Terminology 1/2

- dBm – is a measure of RF Power referred to 1 mW (0 dBm)
  - 10mW(10dBm), 500 mW (27dBm)
- PER – Packet Error Rate [%] – percentage of the packets not successfully received over a period of time
  - Used to measure the RF transceiver performance
- BER – Bit Error Rate [%] - percentage of the Bits not successfully received over a period of time
  - Used to measure the RF transceiver performance
- Sensitivity (RX) – it is the lowest input power of the receiver acceptable to receive packets with 1% PER
- Blocking (RX) – The receiver ability to work in the presence of a interfering RF signal in a frequency band relatively close to the signal of interest

# Basic Terminology 2/2

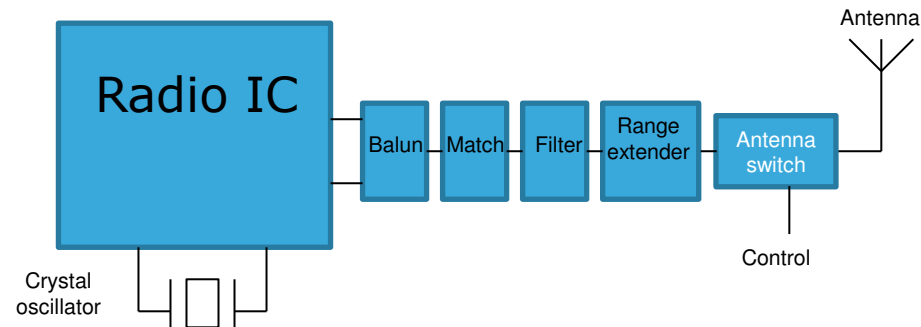
- Dynamic range - the maximum received power variation at the receiver input pins which result in a correct demodulated signal
- Adjacent Channels – channel(s) closest to the active signal channel
- Alternate Channel – second next channel(s) to the active signal channel
- Payload – application data
- Modulation – superimposing algorithm of a low frequency signal (payload) onto a high frequency signal (Carrier)
  - ASK, OOK, FSK, GFSK, GMSK



# RF system

- Radio IC

- Transmitter (only TX)
- Receiver (only RX)
- Transceiver (both TX & RX)
- SoC (Transceiver + MCU)



- Crystal

- Clocks the Radio IC crystal oscillator which generates the reference frequency for the RF synthesizer

- Balun

- converts balanced (differential) signal to unbalanced (single-ended) signal and the vice versa.

- Matching network

- whenever a source of power with a fixed output impedance such as a radio transmitter operates into a load, the maximum possible power is delivered to the load when the impedance of the load is equal to the complex conjugate of the impedance of the source

- Filter

- attenuates out of band signals

- Antenna switching

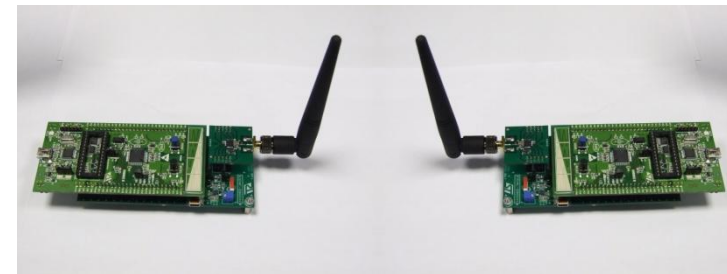
- Either can be used to switch from antenna to antenna with a better RSSI value, or is switching the antenna either to the RX to TX chain between the antenna and the radio IC

- Range Extender

- can be used to increase the radiated output power

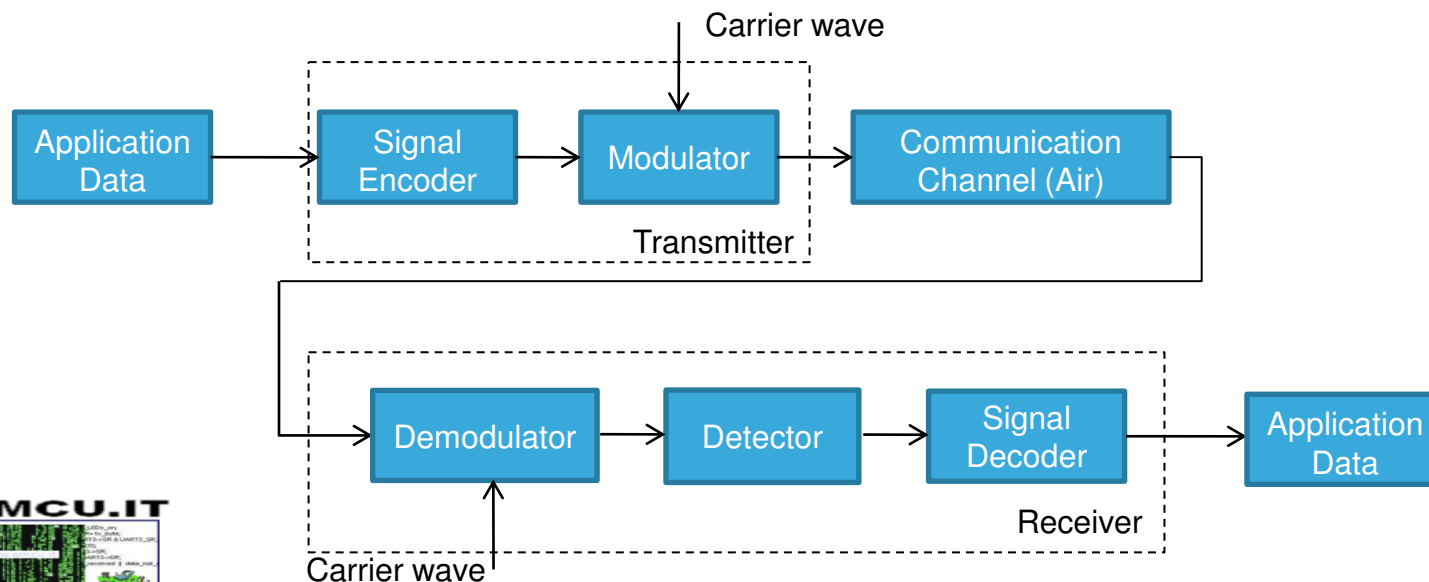
- Antenna

- converts electric power into radio waves



# Complete RF communication environment

- Signal encoder / decoder
  - converts information from one format or code to another, for the purposes of standardization, speed, security or saving space by shrinking size (e.g. Manchester), decoder does the opposite
- Modulator
  - process of varying one or more properties (amplitude, frequency, ...) of a high-frequency periodic waveform, called the carrier wave, with a modulating signal which typically contains information to be transmitted (Application Data)
- Communication channel
  - is the physical transmission medium as a wire or, as in our case, a radio channel
- Demodulator / Detector
  - Recovers the information content from the modulated carrier wave

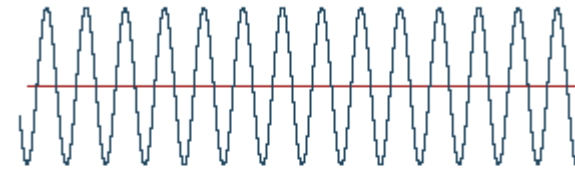


# Digital Amplitude modulation methods

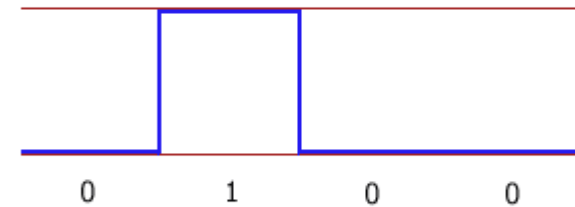
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- ASK (Amplitude Shift Keying)
  - The amplitude of an analog carrier signal varies in accordance with the digital bit stream
  - The amplitude of the carrier is set to a max level when a 1 is sent and a min level when a 0 is sent
  - Simple, duty cycling, lower transmit current
  - Susceptible to noise, wide spectrum
- OOK (ON OFF Keying)
  - It is the simplest form of ASK
  - It represents digital data as the presence or absence of a carrier

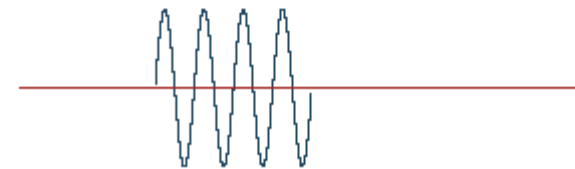
Carrier



Modulating Wave (digital)



Modulated Result



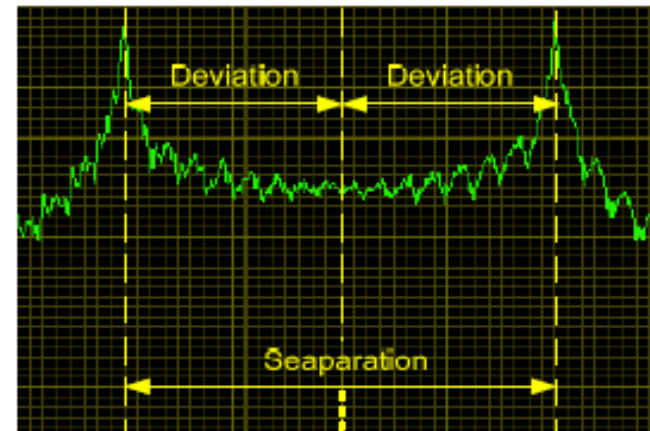
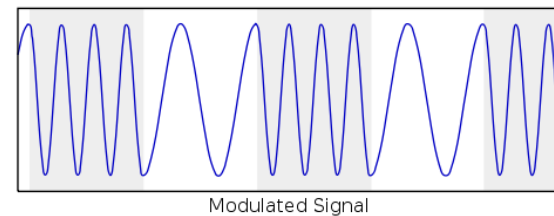
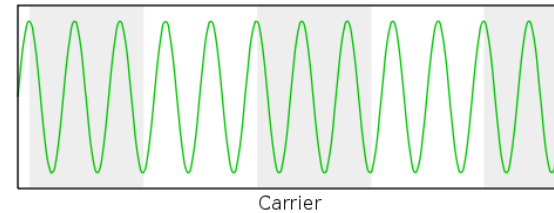
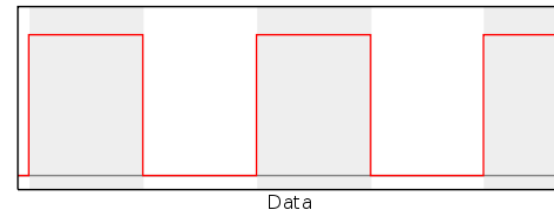
# Digital frequency modulation method (1/2)

- FSK

- The digital information is transmitted through discrete frequency changes of a carrier
- Less susceptible to noise
- Theoretically it requires larger bandwidth than ASK

- 2-FSK (Two level or binary FSK)

- A pair of discrete frequencies is used to transmit 1/0



# Digital frequency modulation method (2/2)

- GFSK (Gaussian FSK)
  - A Gaussian filter smoothes baseband data (1/0) to make the pulse smoother
  - It has better spectral width than 2-FSK
- MSK and GMSK
  - MSK (Minimum Shift Keying)
    - Is a type of continuous-phase frequency-shift keying (CP-FSK)
    - Is implemented as a fast frequency-shift keying (FFSK)
    - The results is a constant-modulus signal => reduces problems caused by distortion
  - GMSK (Gaussian Minimum Shift Keying)
    - A Gaussian filter is applied to smooth the incoming digital data

