Digital Modulation

Amplitude Shift Keying, Frequency Shift Keying

Sihat Afnan Farhana Khan

Department of Computer Science & Engineering
Bangladesh University of Engineering and Technology

June, 2021

Introduction

- Digital Communication
  - Noise Immunity
  - Economic $\rightarrow$ Profitable
  - Viability of distortionless regenerative repeaters
- But ... digital signals cannot be directly transmitted
- Solution?

Introduction

- Digital Communication
  - Noise Immunity
  - Economic $\rightarrow$ Profitable
  - Viability of distortionless regenerative repeaters
- But ... digital signals cannot be directly transmitted
- Solution?

Digital Modulation

- **Digital Modulation**
  - Encoding Digital information
  - Modifying carrier wave $\rightarrow$ Amplitude, Frequency, Phase

- Methods of Digital Modulation $\rightarrow$ **ASK**, **FSK**, PSK, BPSK etc.

Digital Modulation

- **Digital Modulation**
  - Encoding Digital information
  - Modifying carrier wave $\rightarrow$ Amplitude, Frequency, Phase

- Methods of Digital Modulation $\rightarrow$ **ASK**, **FSK**, PSK, BPSK etc.

Amplitude Shift Keying (ASK)

Amplitude Shift Keying

- Simplest
- Carrier wave
  - Analog
  - High frequency
- A digital signal $\rightarrow$ changes amplitude of carrier

Amplitude Shift Keying (ASK)

Amplitude Shift Keying

- Simplest
- Carrier wave
  - Analog
  - High frequency
- A digital signal $\rightarrow$ changes amplitude of carrier

Amplitude Shift Keying (ASK)

Amplitude Shift Keying

- Simplest
- Carrier wave
  - Analog
  - High frequency
- A digital signal $\rightarrow$ changes amplitude of carrier

Amplitude Shift Keying (ASK)

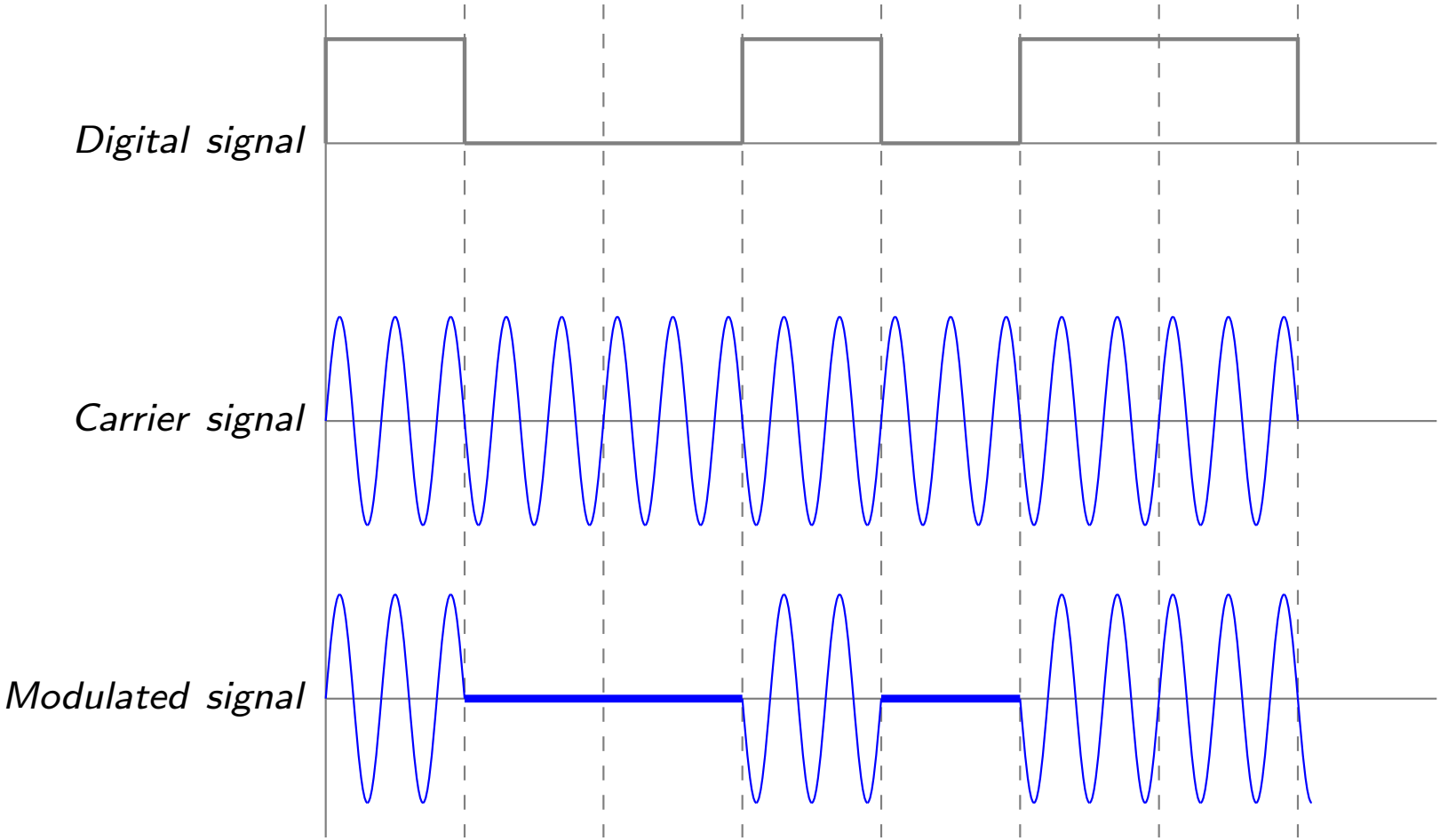


Figure: Binary signal modulation with ASK

Amplitude Shift Keying (ASK)

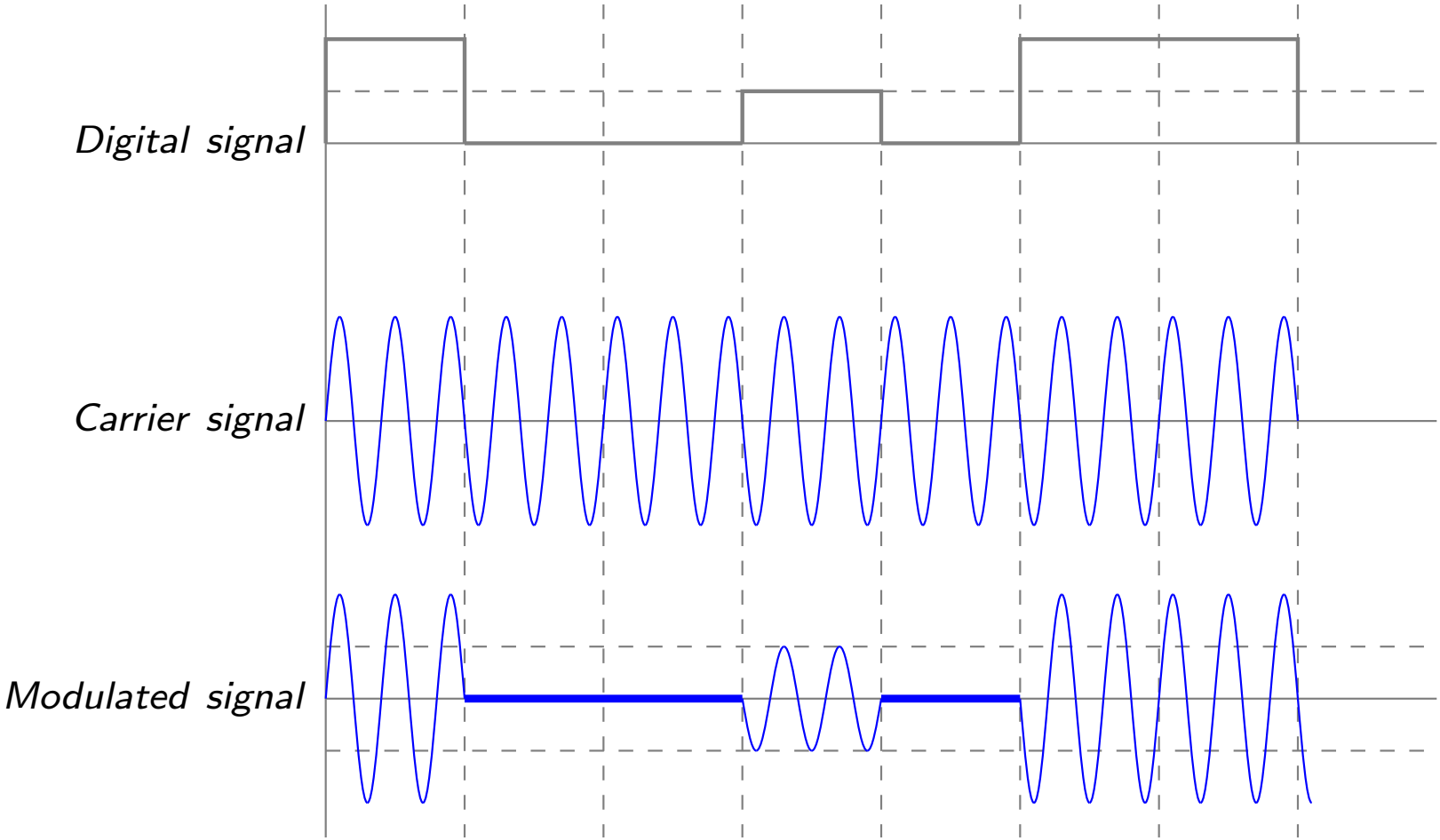
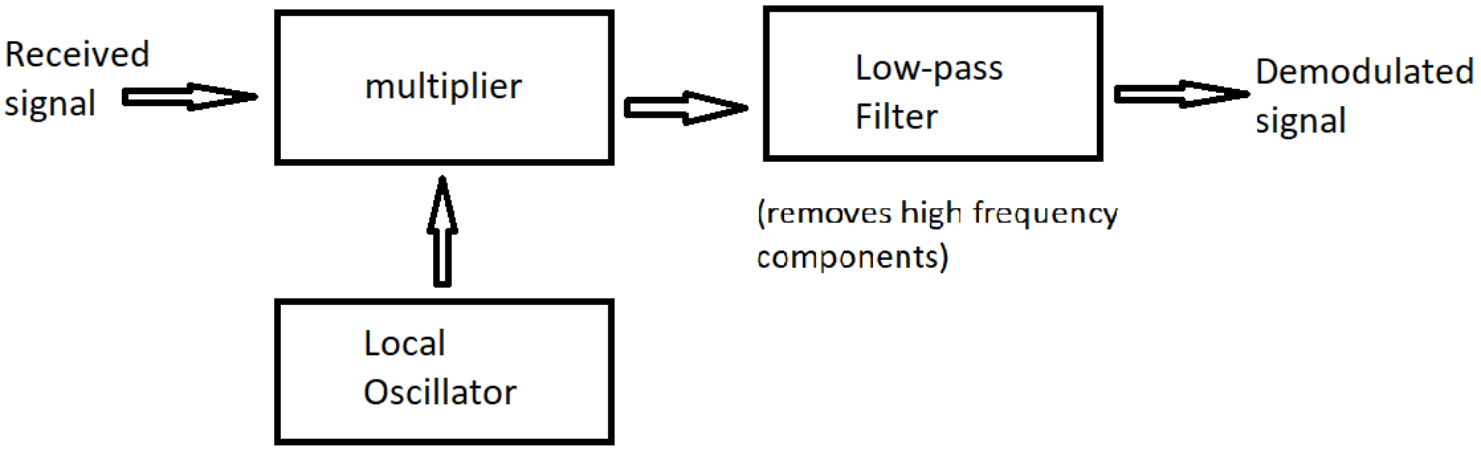


Figure: Multilevel signal modulation with ASK

Amplitude Shift Keying (ASK)

Demodulation of ASK

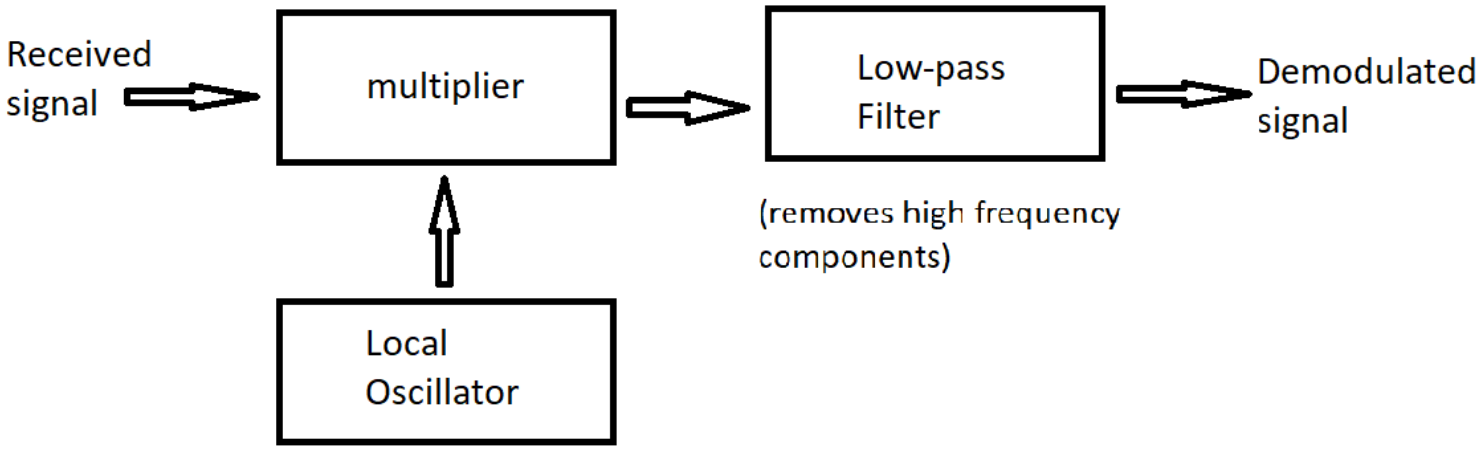
- **Coherent Detection**



Amplitude Shift Keying (ASK)

Demodulation of ASK

- **Coherent Detection**

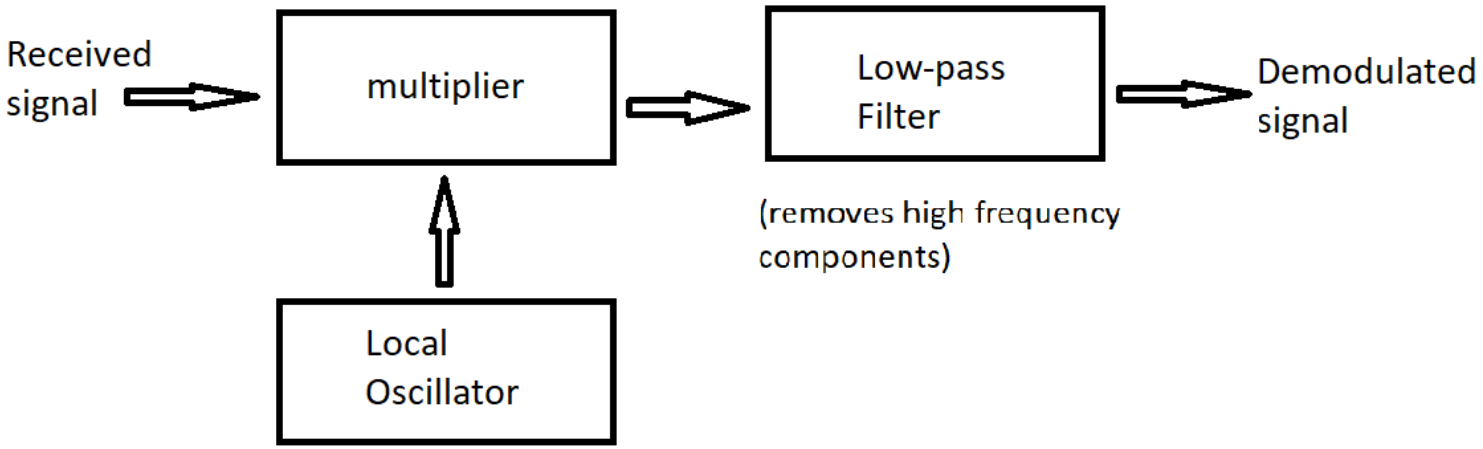


- Synchronous
- Using Oscillator

Amplitude Shift Keying (ASK)

Demodulation of ASK

- **Coherent Detection**

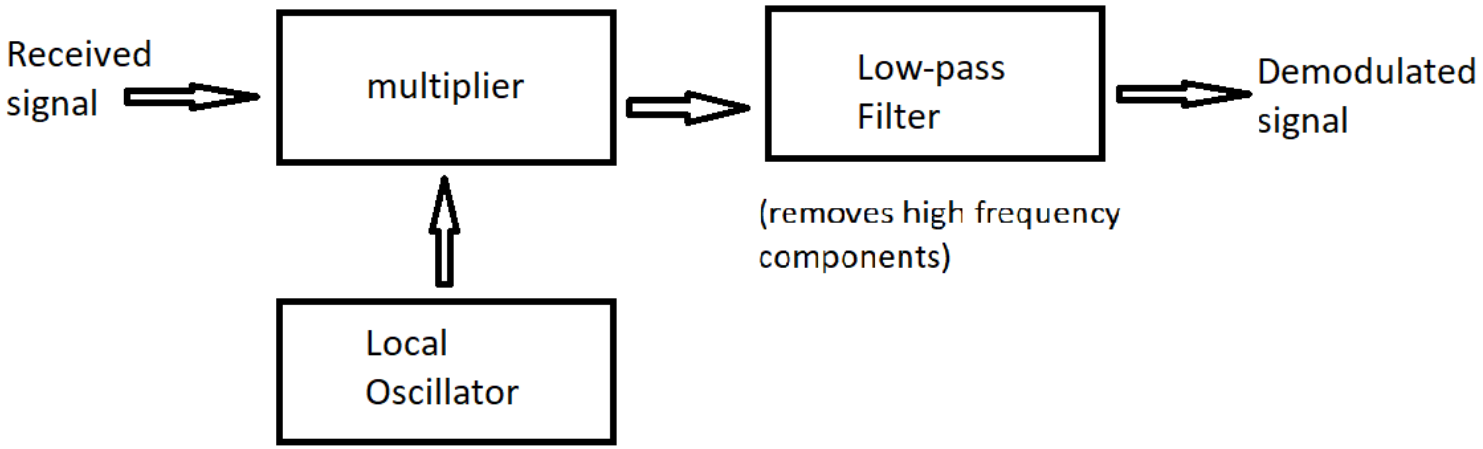


- Synchronous
- Using Oscillator
- Efficient

Amplitude Shift Keying (ASK)

Demodulation of ASK

- **Coherent Detection**

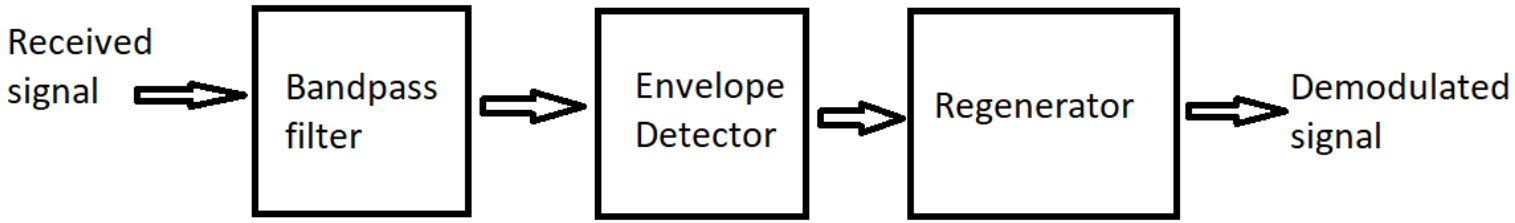


- Synchronous
- Using Oscillator
- Efficient
- Costly

Amplitude Shift Keying (ASK)

Demodulation of ASK

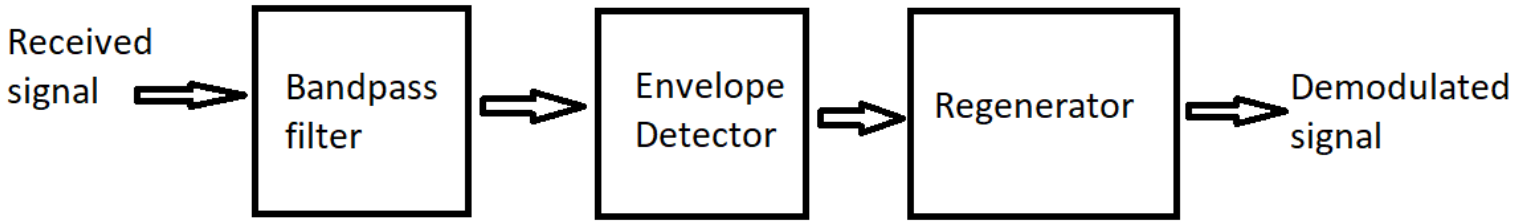
- **Non coherent Detection**



Amplitude Shift Keying (ASK)

Demodulation of ASK

- **Non coherent Detection**

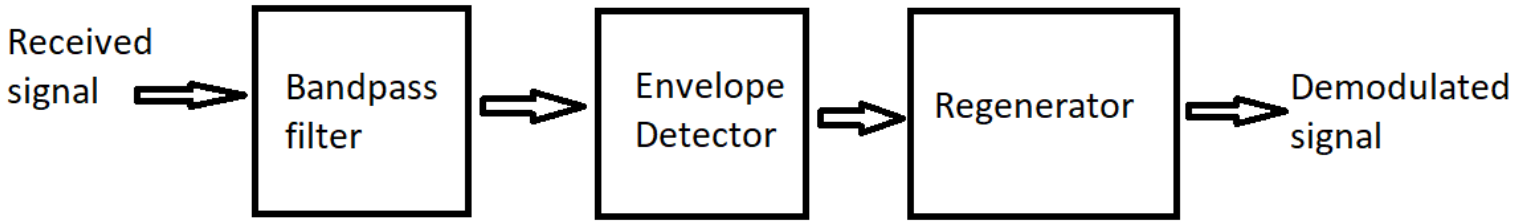


- Asynchronous
- Using Envelope detector

Amplitude Shift Keying (ASK)

Demodulation of ASK

- **Non coherent Detection**

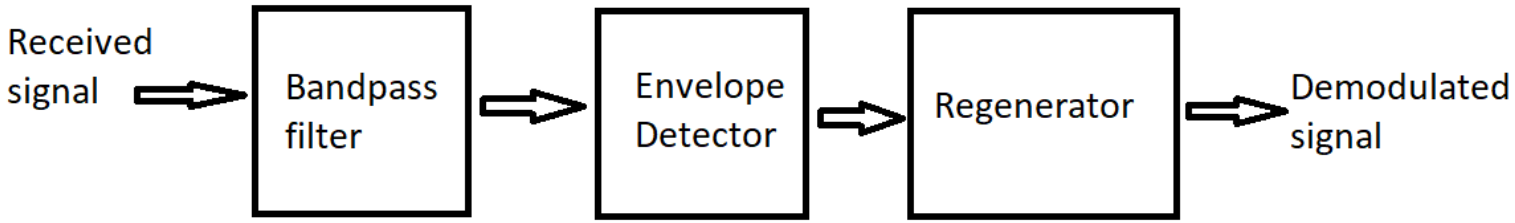


- Asynchronous
- Using Envelope detector
- Less costly

Amplitude Shift Keying (ASK)

Demodulation of ASK

- **Non coherent Detection**



- Asynchronous
- Using Envelope detector
- Less costly
- Poor performance with less SNR

Amplitude Shift Keying (ASK)

- **Applications**

Amplitude Shift Keying (ASK)

- **Applications**
  - Broadcasting digital signal

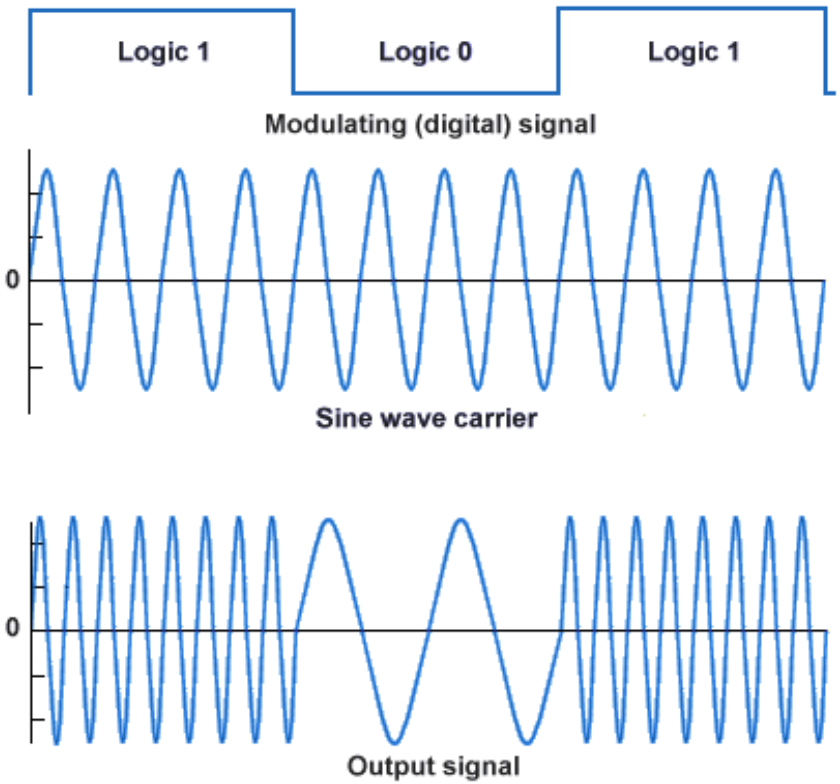
Amplitude Shift Keying (ASK)

- **Applications**
  - Broadcasting digital signal
  - In optical fiber communication for LASER intensity modulation

Amplitude Shift Keying (ASK)

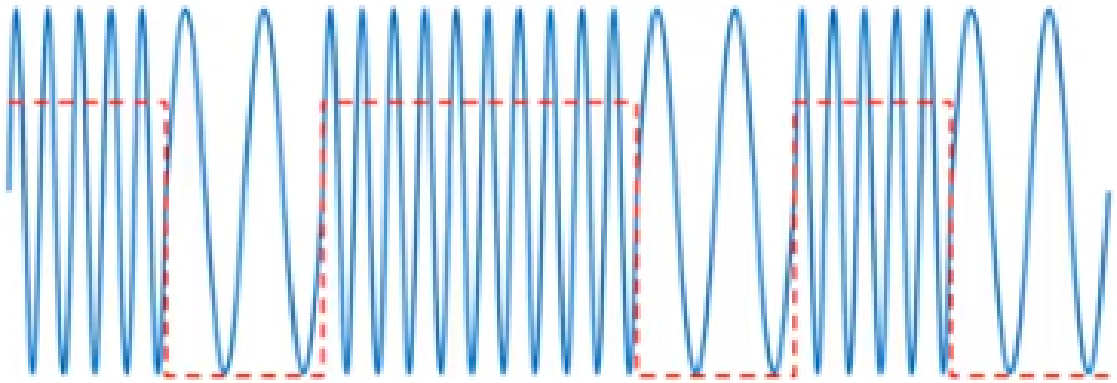
- **Applications**
  - Broadcasting digital signal
  - In optical fiber communication for LASER intensity modulation
  - Transmit Morse codes

Frequency Shift Keying



Frequency Shift Keying

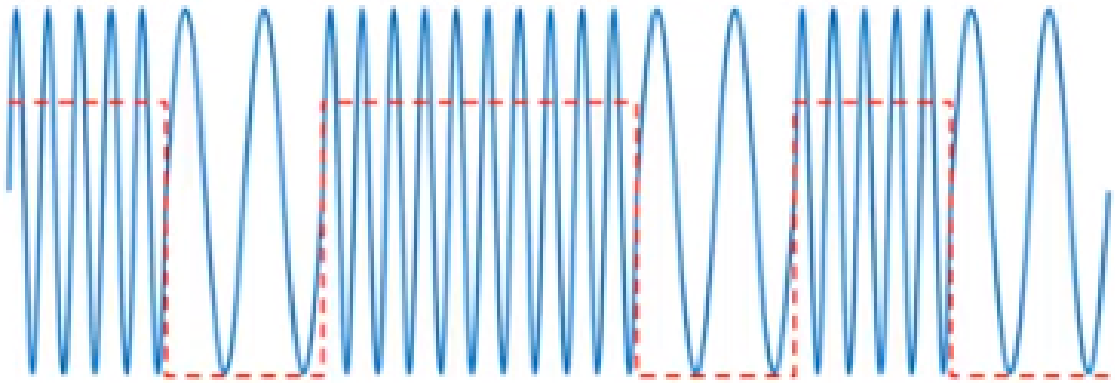
1. Discrete variation of carrier signal frequency.



2. Different from the continuous variation of carrier signal frequency in analog FM modulation.
3. Number of discrete frequencies can be
   - two : Binary FSK or BFSK
   - More than two : M-ary FSK

Frequency Shift Keying

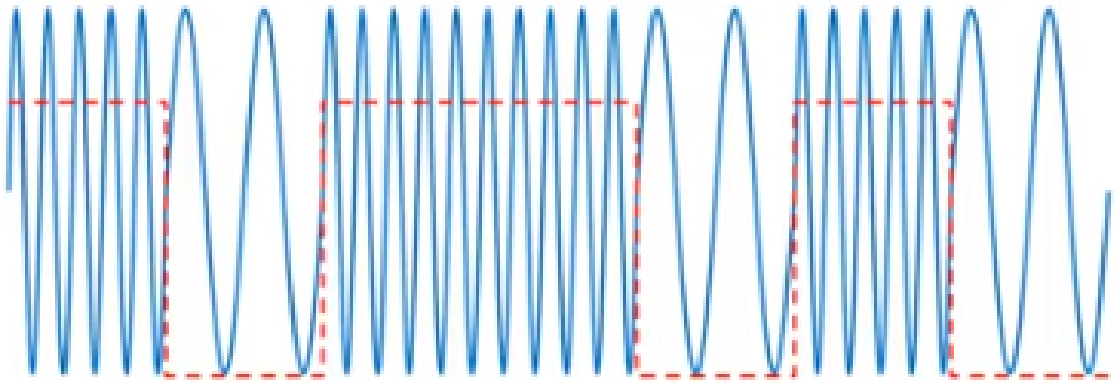
1. Discrete variation of carrier signal frequency.



2. Different from the continuous variation of carrier signal frequency in analog FM modulation.
3. Number of discrete frequencies can be
   - two : Binary FSK or BFSK
   - More than two : M-ary FSK

Frequency Shift Keying

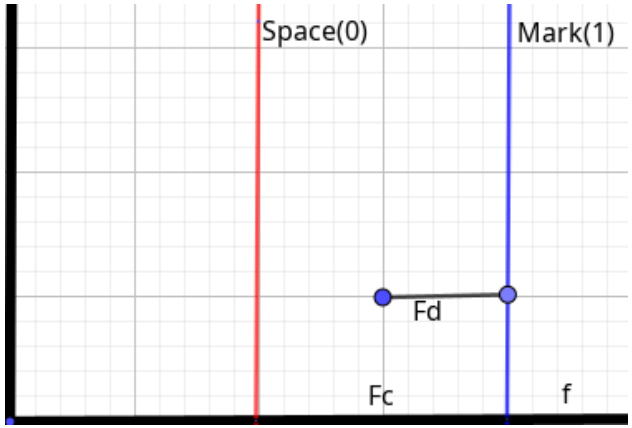
1. Discrete variation of carrier signal frequency.



2. Different from the continuous variation of carrier signal frequency in analog FM modulation.
3. Number of discrete frequencies can be
   - two : Binary FSK or BFSK
   - More than two : M-ary FSK

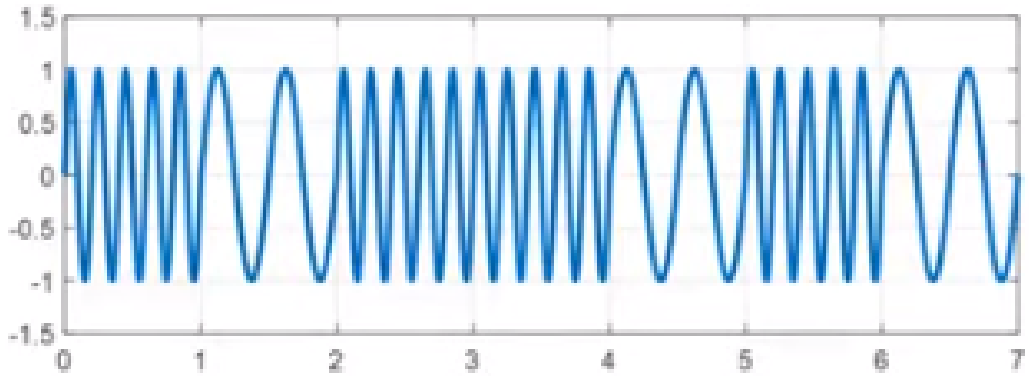
BFSK

1. Two frequencies : Mark and Space
2. Same amount of deviation from the carrier frequency f_c



BFSK

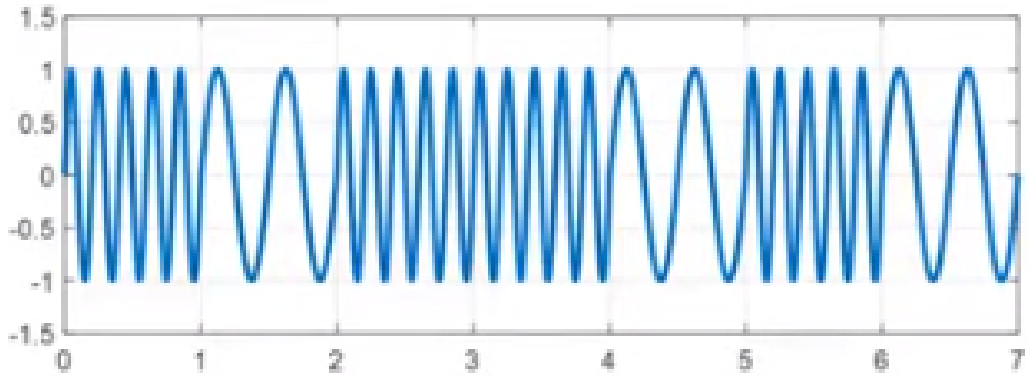
1. Carrier amplitude doesn't change(only frequency)



2. Simplifies the amplifier design and selection

BFSK

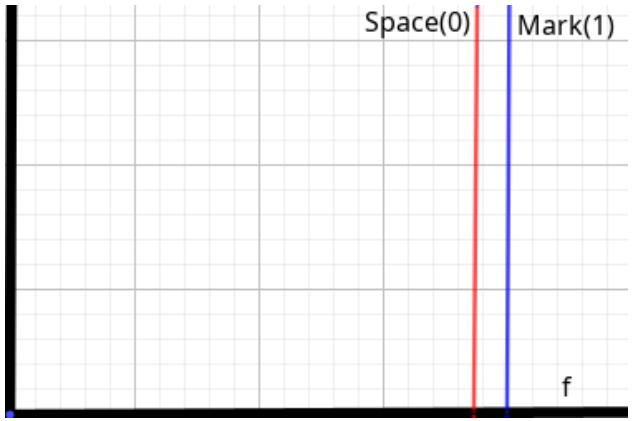
1. Carrier amplitude doesn't change(only frequency)



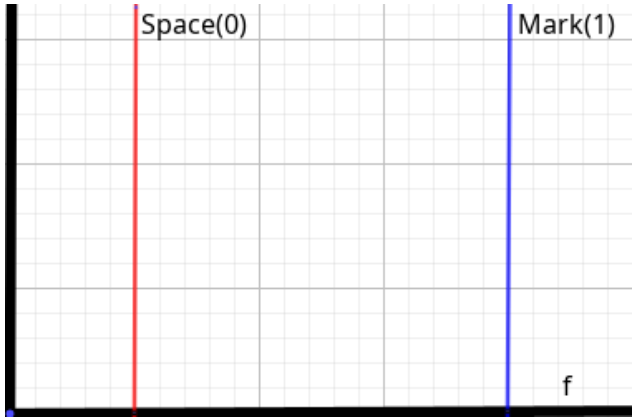
2. Simplifies the amplifier design and selection

Tone Spacing

- How far apart should the mark an space be?
  - Too close - InterSymbol interference(ISI)

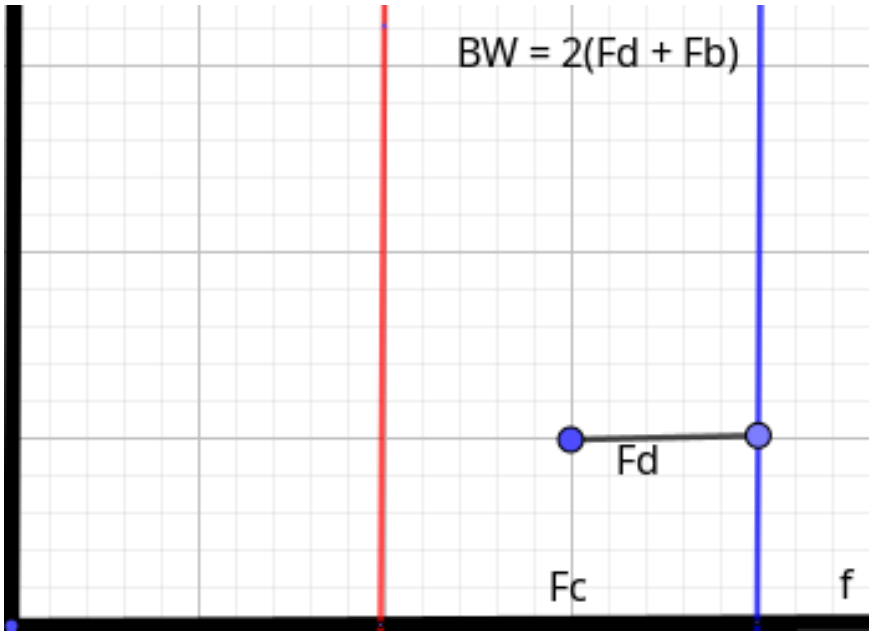


  - Too far - Excessive Bandwith



Minimum FSK Bandwith

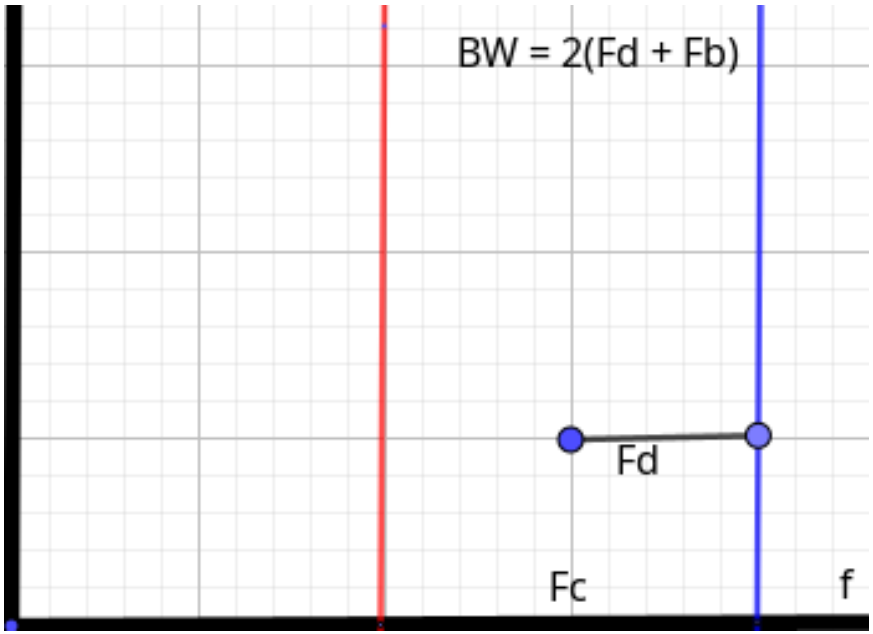
1. Function of
   - Frequency Deviation(F_d)
   - Bit Rate(F_b)



2. But how far apart the tone should be?

Minimum FSK Bandwith

1. Function of
   - Frequency Deviation(F_d)
   - Bit Rate(F_b)



2. But how far apart the tone should be?

Modulation Index

1. Tones should be as close as possible without creating ISI.
2. Modulation Index

$$h = \frac{2 * F_d}{F_b}$$

3. Optimal detetction occurs when h$\geq$ 1
4. Why MSK needs less bandwith than BFSK for a given bit rate?

Modulation Index

1. Tones should be as close as possible without creating ISI.
2. Modulation Index

$$h = \frac{2 * F_d}{F_b}$$

3. Optimal detetction occurs when h$\geq$ 1
4. Why MSK needs less bandwith than BFSK for a given bit rate?

Modulation Index

1. Tones should be as close as possible without creating ISI.
2. Modulation Index

$$h = \frac{2 * F_d}{F_b}$$

3. Optimal detetction occurs when h$\geq$ 1
4. Why MSK needs less bandwith than BFSK for a given bit rate?

Modulation Index

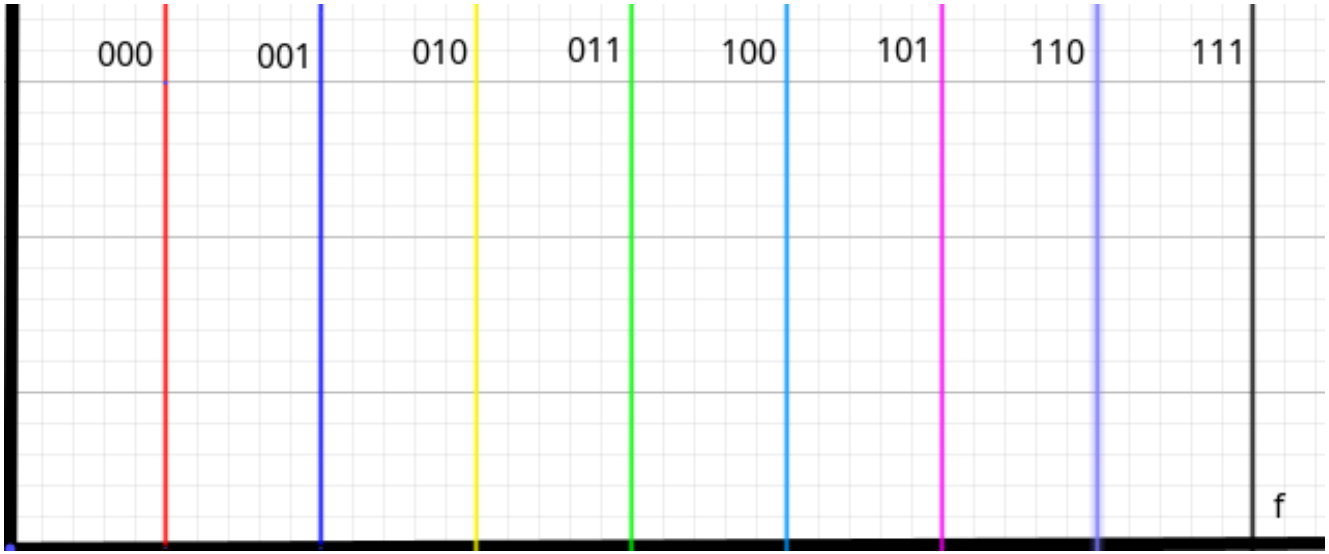
1. Tones should be as close as possible without creating ISI.
2. Modulation Index

$$h = \frac{2 * F_d}{F_b}$$

3. Optimal detetction occurs when h$\geq$ 1
4. Why MSK needs less bandwith than BFSK for a given bit rate?

MFSK

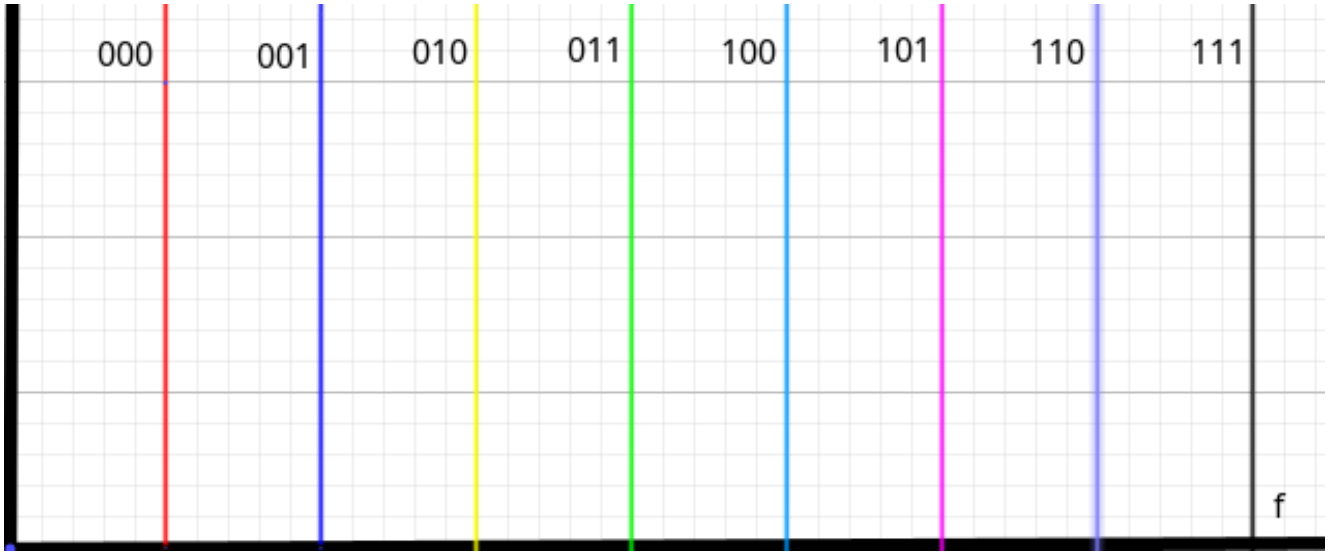
1. More than two frequencies



2. Each MFSK tone corresponds to $\log_2 M$ bits
3. BFSK Formulas are applicable for MFSK too.

MFSK

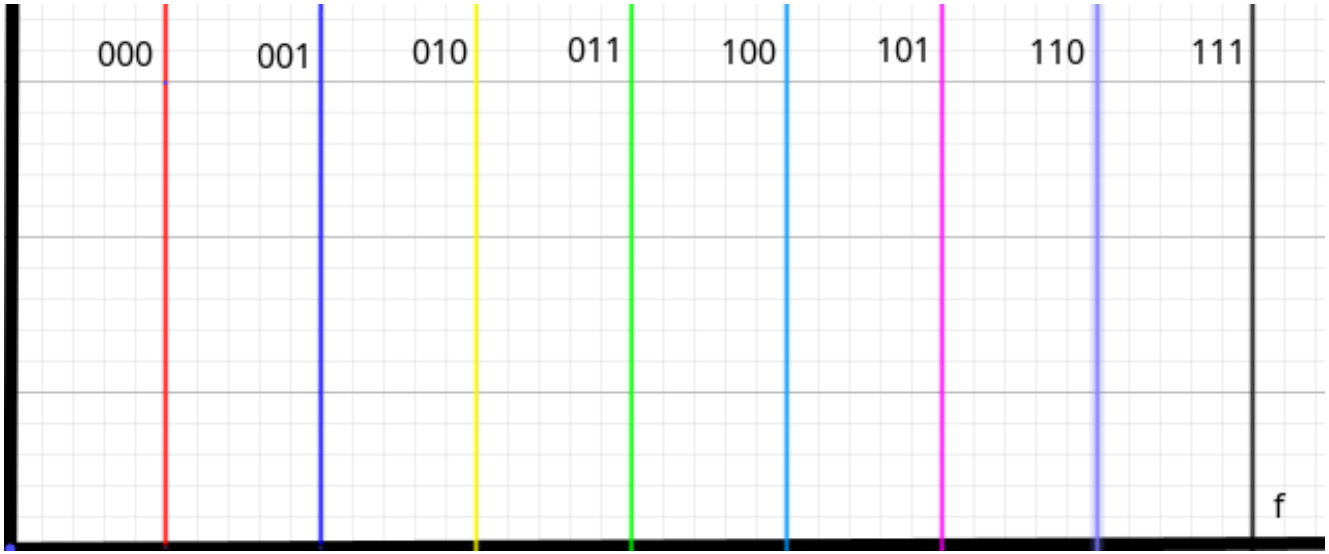
1. More than two frequencies



2. Each MFSK tone corresponds to $\log_2 M$ bits
3. BFSK Formulas are applicable for MFSK too.

MFSK

1. More than two frequencies



2. Each MFSK tone corresponds to $\log_2 M$ bits
3. BFSK Formulas are applicable for MFSK too.

Application of FSK

1. *Paging*($F_d \uparrow, F_b \downarrow$)

2. Digital Radio Technology
3. Data Collection and Remote Controls

The End

Thank You

Any Question?