PM AND PSK

WHY MODULATING ?

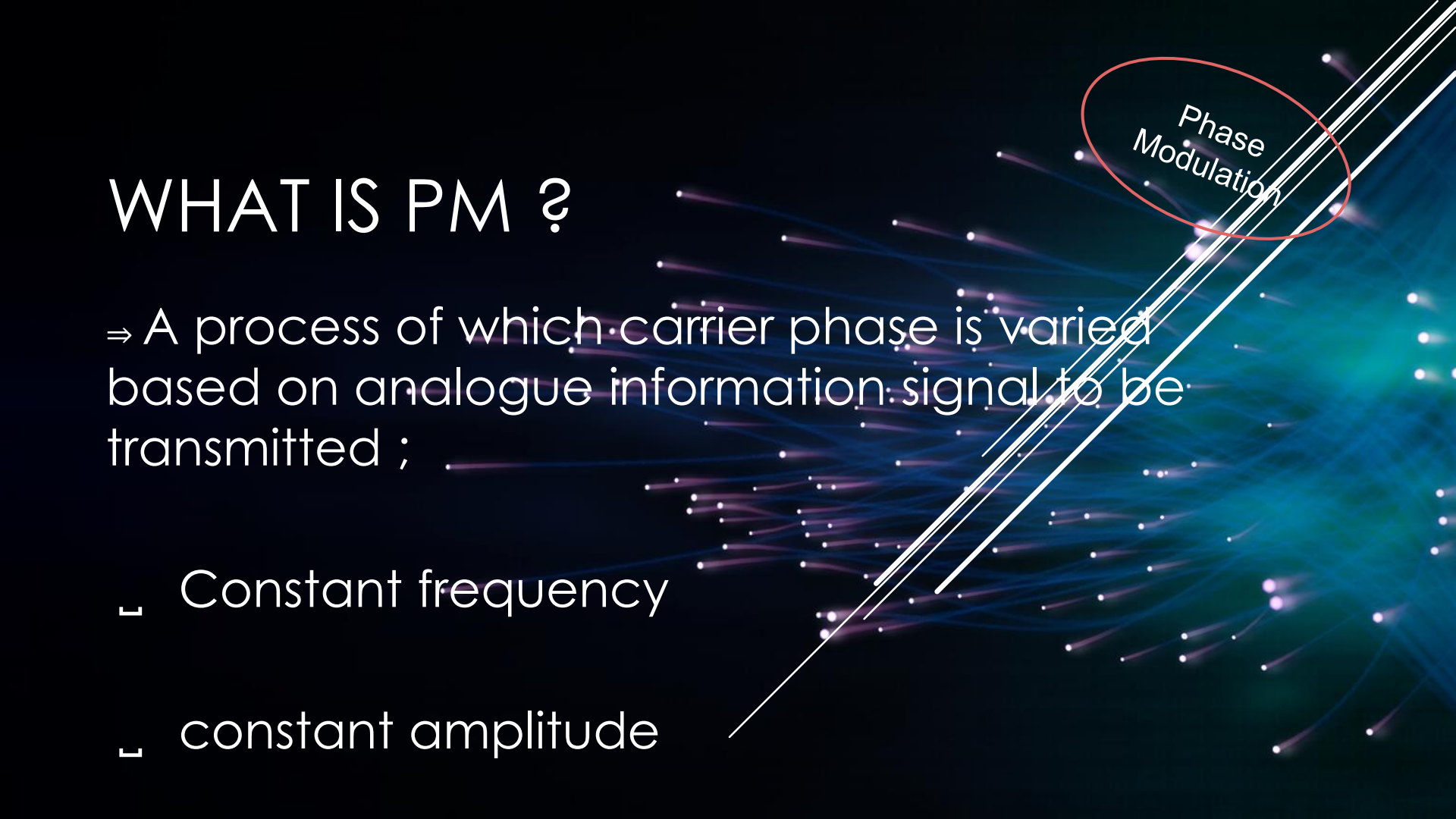
- The signal received needs antennas with the same dimension order as the carrier wave. We have to use high frequencies to get small carrier waves and so we will need quite small antennas. ⇒ HF carrier
- At audible frequencies, the radiation efficiency is poor so we require to increase the frequency of the wave. ⇒ HF carrier
- The frequency of noises such as thermal noises and electromagnetic noises lies in the range of audible frequency, modulation allows to avoid theses noises ⇒ HF carrier
- The energy of any wave depends upon its frequency. For small signal frequency, power is lower so it cannot be transmitted over large distances ⇒ HF carrier

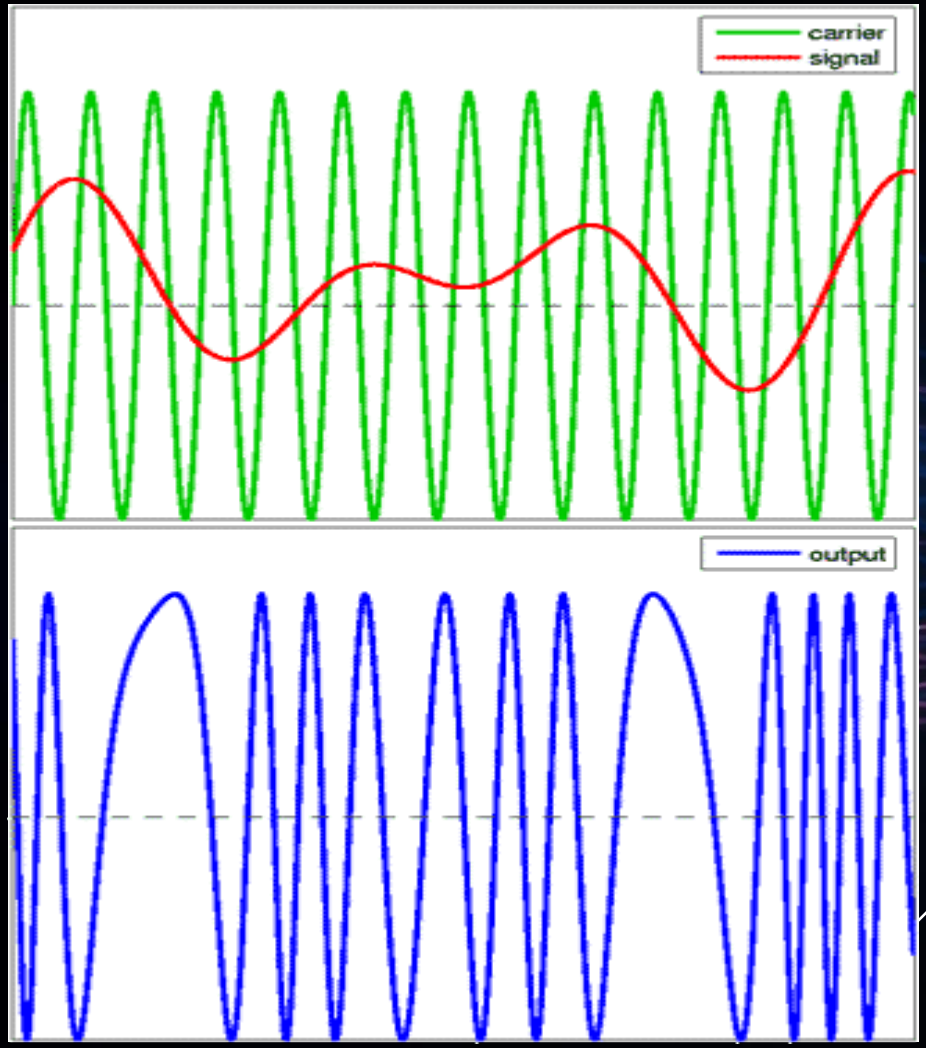
⇒ we need high frequency carrier to transmit the information

WHAT IS PM ?

⇒ A process of which carrier phase is varied based on analogue information signal to be transmitted ;

- Constant frequency
- constant amplitude





WHAT IS PM GRAPHICALLY ?

HISTORY

MATHEMATICAL CONCEPT OF PM

Modulated carrier signal : $Vc(t) = Vc \cos\boldsymbol{\Phi}(t)$

With $\boldsymbol{\Phi}(t) = \boldsymbol{\omega_c t + K_p V_m}$ K_p is the constant of proportionality for PM

So, phase modulated carrier : $Vc(t) = Vc \cos[\omega_c t + K_p V_m(t)$

For PM, modulated carrier is proportional to modulating signal,

$\Delta\boldsymbol{\Phi}(t)=K_p V_m \cos\omega_m t$

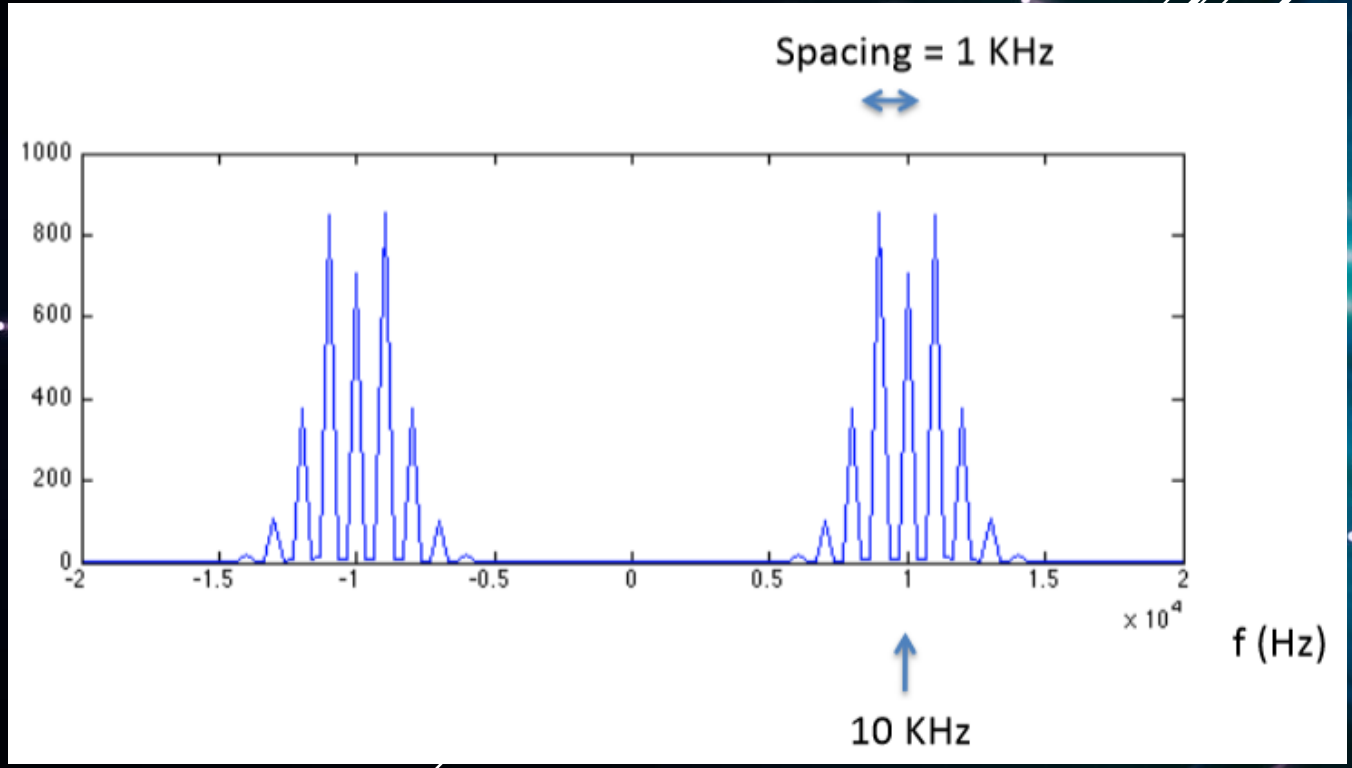
Phase modulated signal : $V_{pm}(t) = Vc \cos[\omega_c t + K_p V_m \cos\omega_m t$

FREQUENCY DOMAIN OF THE PM SIGNAL

Example :

1 KHz sinusoidal baseband signal

10 KHz carrier



PM ELECTRIC INSTALLATION

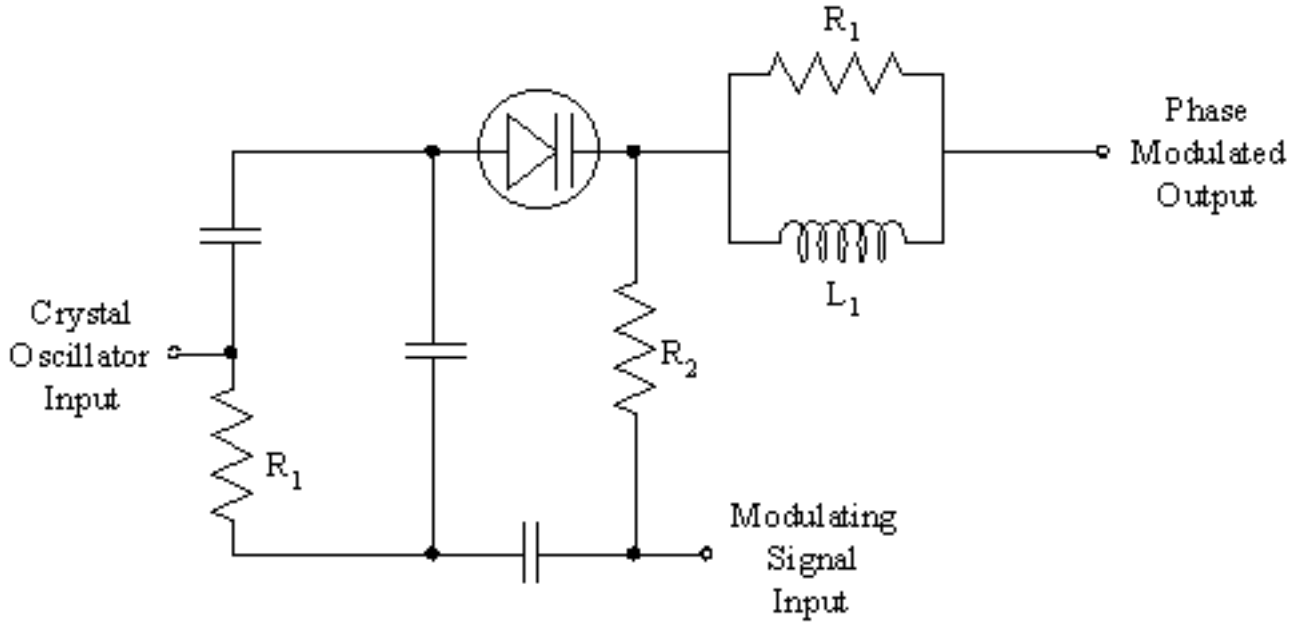


Figure 3 Varactor Diode Circuit for Phase Modulation

APPLICATIONS

PM is used for signal and waveform generation in digital synthesizers, such as the Yamaha DX7 to implement FM synthesis. phase distortion is used in the Casio CZ synthesizers.

APPLICATIONS

It is also used in signal transmission system in army back then. It transmits video signal along with audio signal. They make the use of special receiver device that can receive and demodulate audio and video

ADVANTAGES AND DISADVANTAGES

Advantages

- Phase modulation and demodulation is easier than using frequency method

Disadvantages

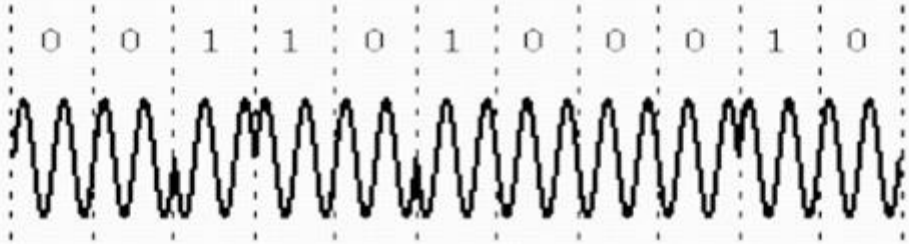
Phase ambiguity comes if we exceed its modulation index pi radian (180)

WHAT IS PSK ?

⇒ **One of the digital modulation technique for transmission of digital data**

- **digital signal**
- **the more the bits per symbol, the better it is**

MATHEMATICAL CONCEPT OF PSK



$$s(t) = \begin{cases} A\cos(2\pi f_c t + \pi) \\ A\cos(2\pi f_c t) \end{cases}$$

Upper formula is used at 1

Lower formula is used at 0

TYPES OF PSK

$$constellation \in \begin{cases} BPSK & 1bit/symbol \\ QPSK & 2bits/symbol \\ 16-QAM & 4bits/symbol \\ 64-QAM & 6bits/symbol \\ 256-QAM & 8bits/symbol \\ 1024-QAM & 10bits/symbol \\ \dots & \dots \end{cases}$$

TYPES OF PSK

1). BPSK (Binary phase-shift keying) : simplest method

using 2 phases separated of 180°

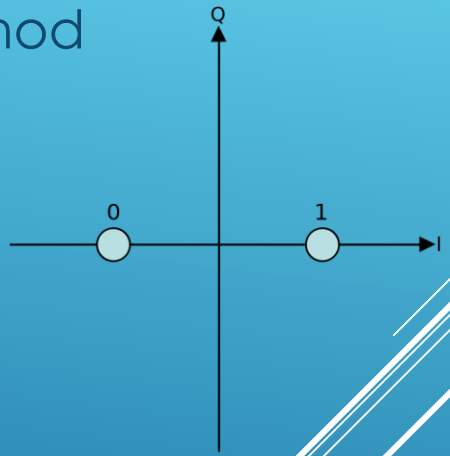
only 1 bit per symbol

/!\ Difficulties if the constellation is rotated

very reliable

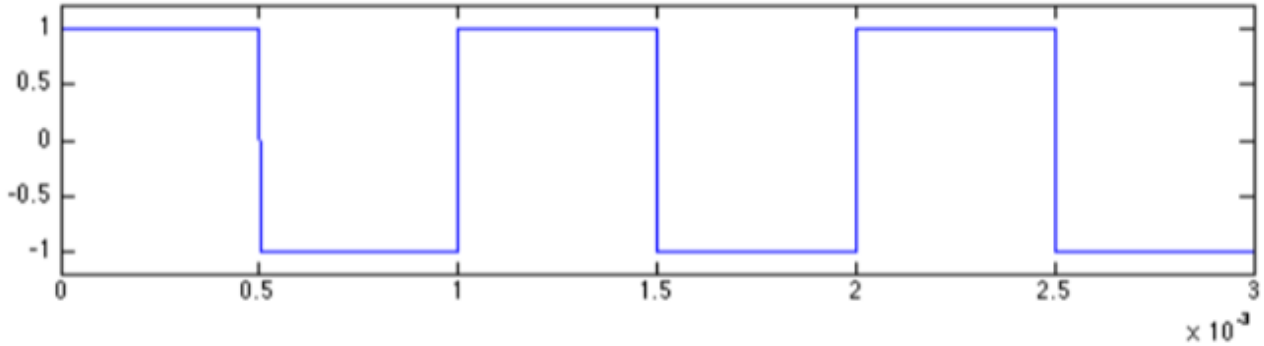
it takes a big deformation to make the demodulator err symbol

low bit rate

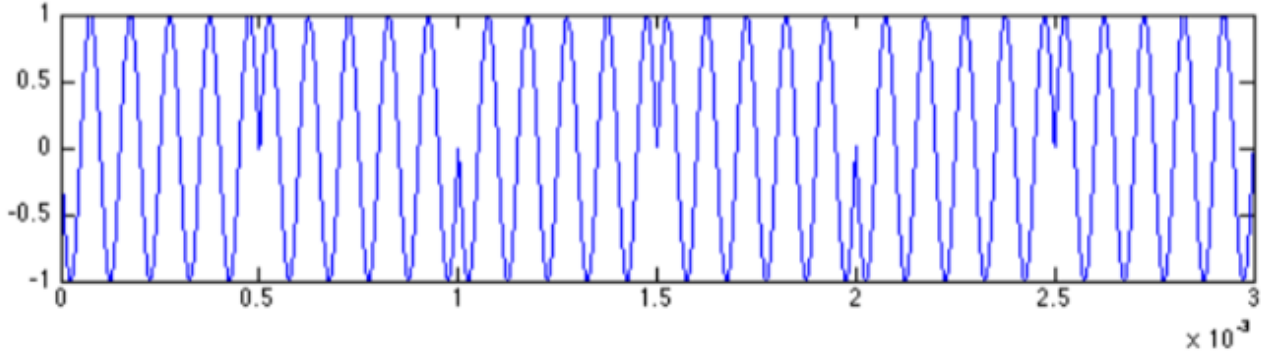


EXAMPLES OF BPSK

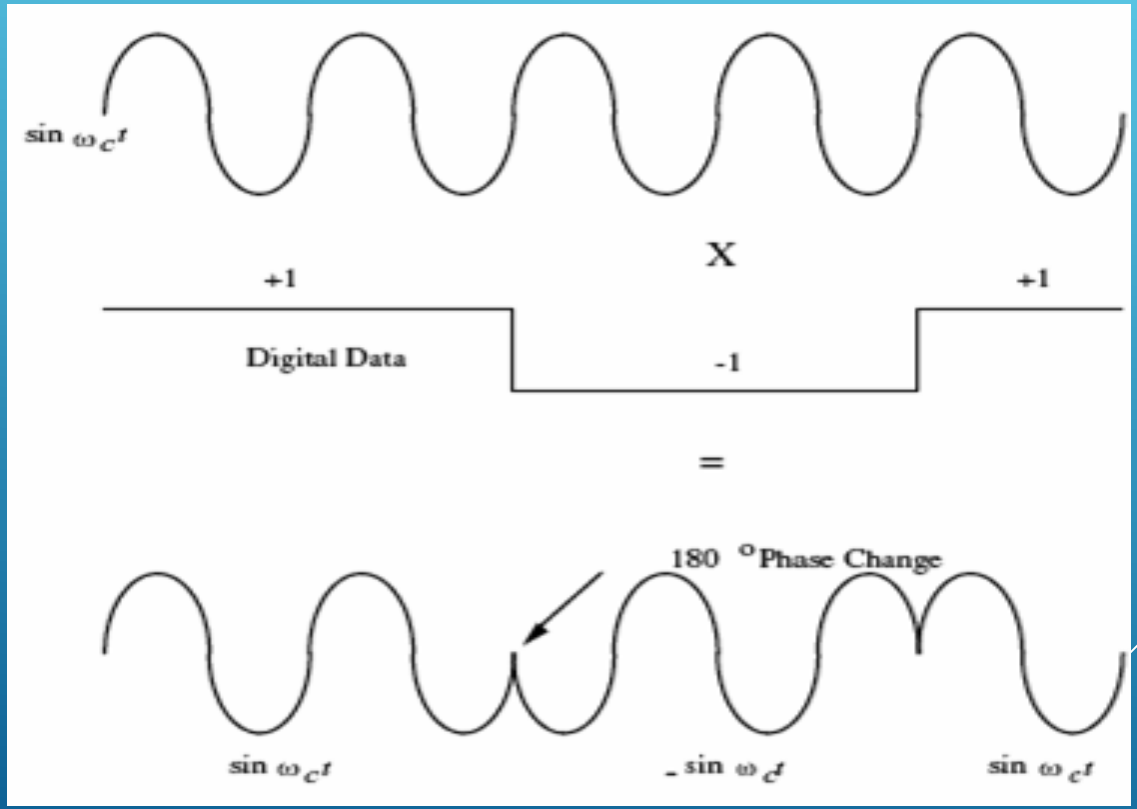
Baseband signal, x(t)



PM signal

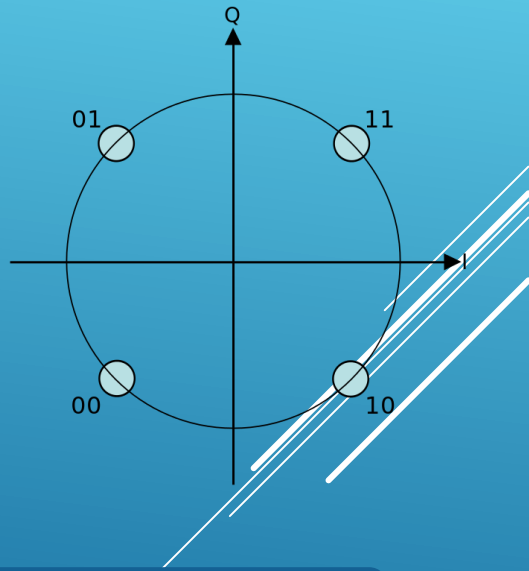


EXAMPLES OF BPSK



2). QPSK (Quadrature phase-shift keying) :

using a 4 points constellation diagram



2 bits per symbol

usually uses the Gray code
00 01 11 10

/!\ Difficulties if the constellation is rotated

doubles the bit rate

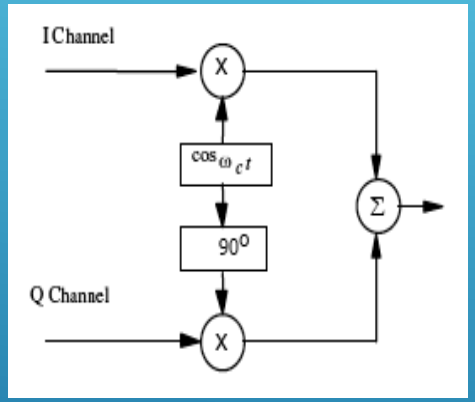
with the same bandpass as BPSK

or

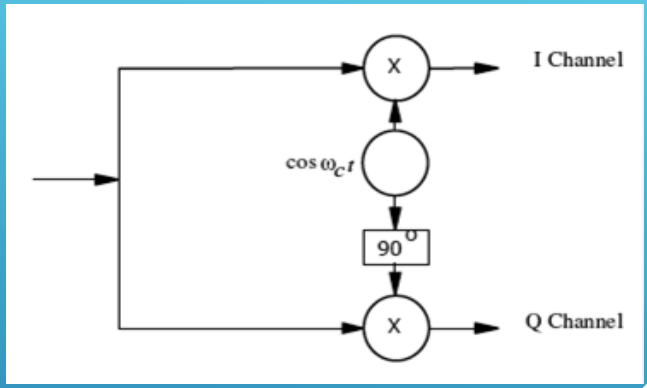
reduced the bandpass by 2

with the same bit rate as BPSK

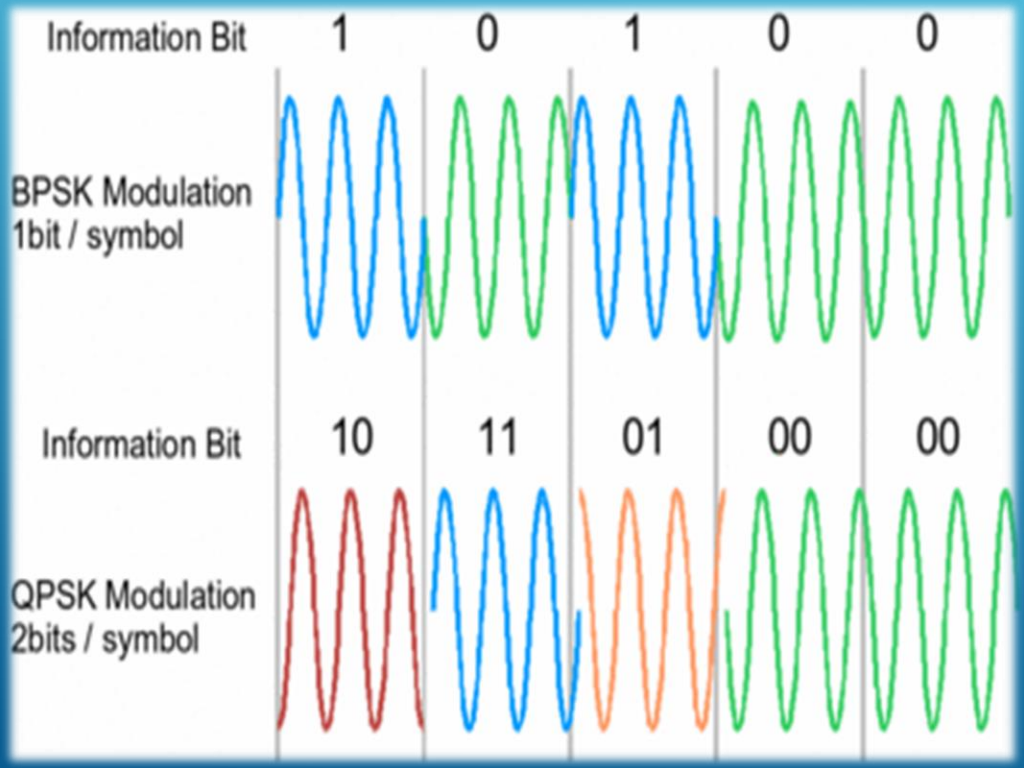
2). QPSK (Quadrature phase-shift keying) :

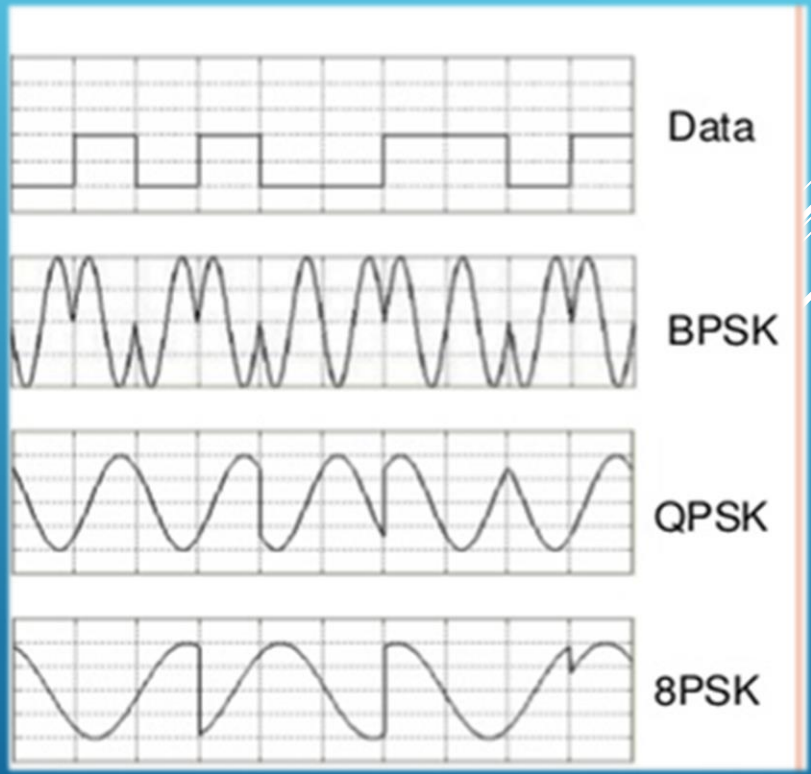


modulation
demodulation



GRAPHICAL COMPARISON





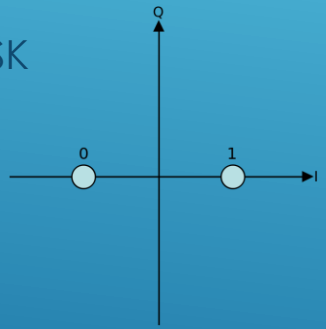
UNDERSTANDING THE QPSK

We want to send 2 bits with only one symbol...

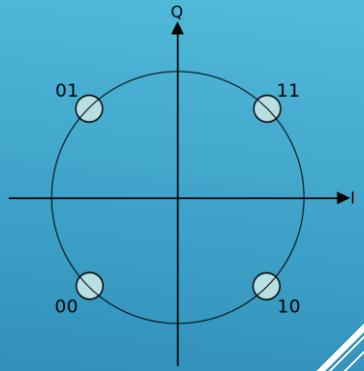
1 bit => 2 possible values => 2 phases needed needed

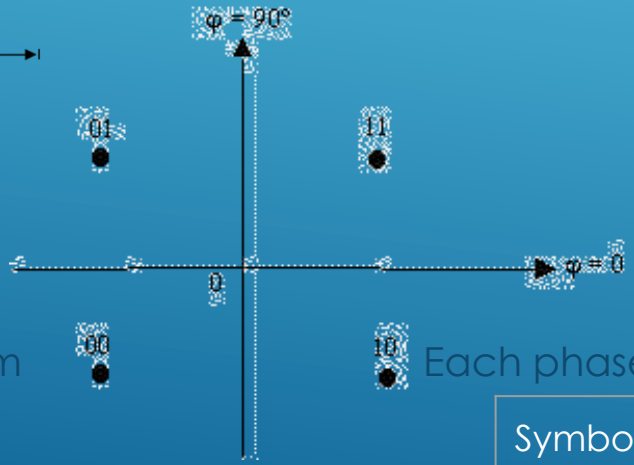
2 bits => 4 possible values => 4 phases

BPSK



QPSK





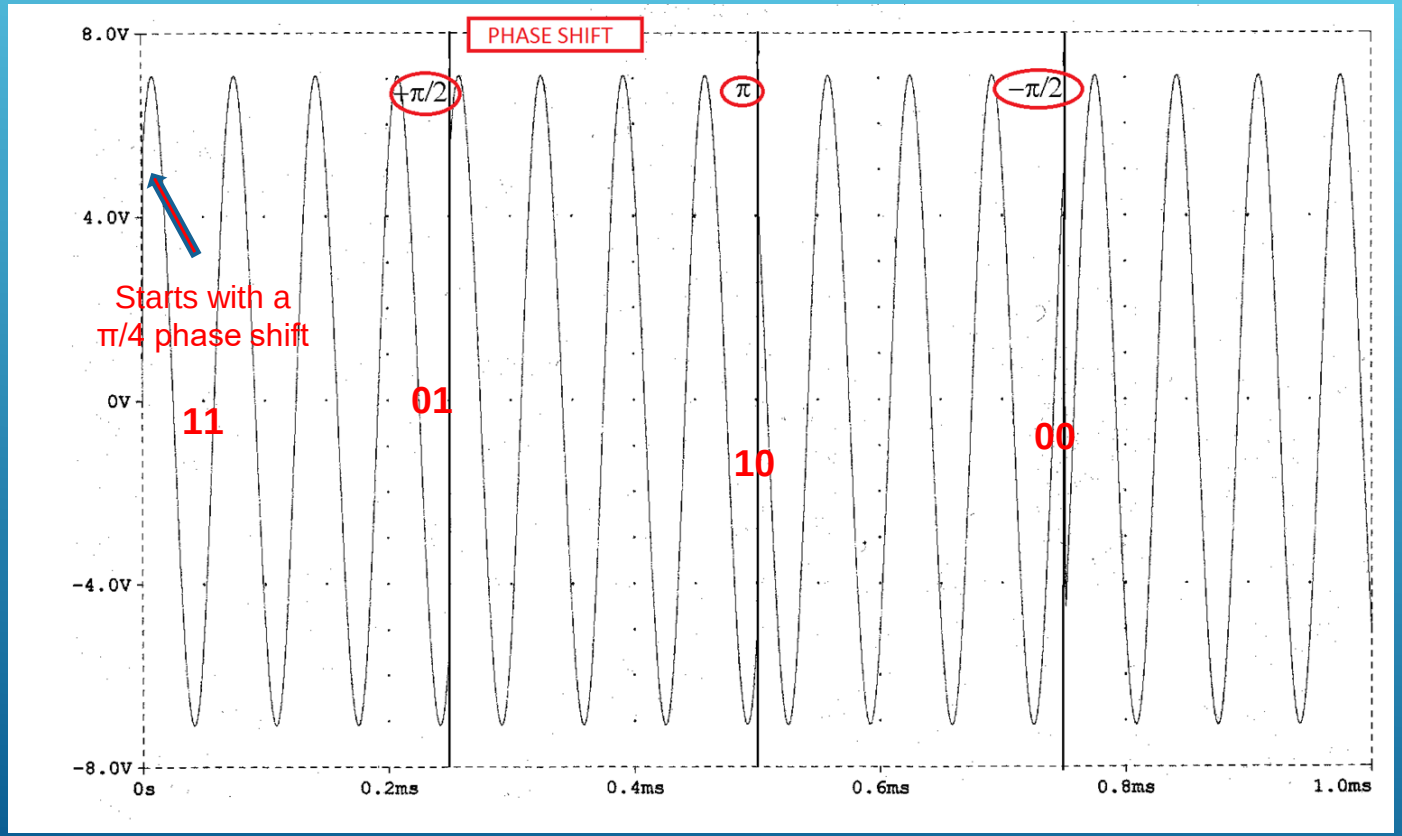
Fresnel diagram

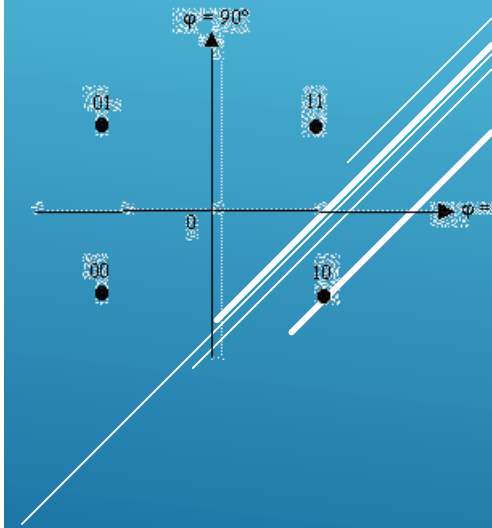
Each phase φ codes for one symbol

Symbol	00	01	11	10
φ (rad)	5π/4	3π/4	π/4	7π/4

UNDERSTANDING THE QPSK

Symbol	00	01	11	10
φ (rad)	5π/4	3π/4	π/4	7π/4





TYPES OF PSK

4). DPSK (Differential phase-shift keying) :

using the phase difference from the previous symbol

example with differential BPSK on the next slide

rules the problem of rotated constellation

difficulties if a symbol is lost

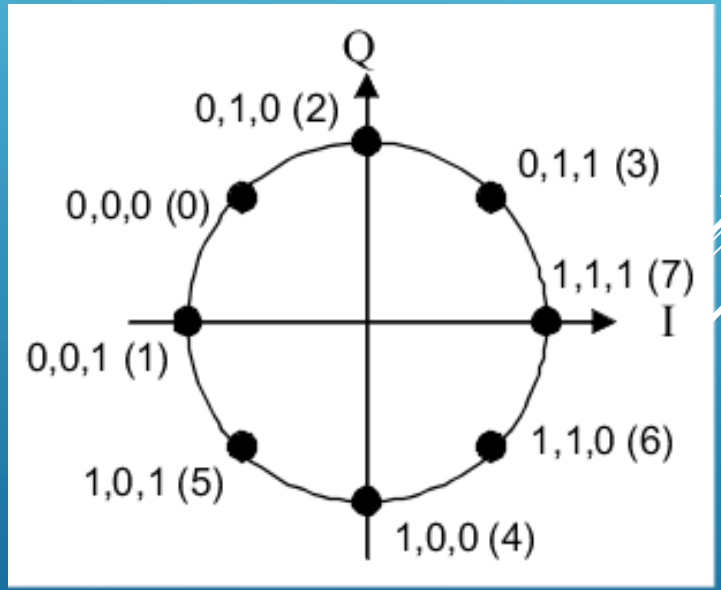
4). DPSK (Differential phase-shift keying) :

Differential BPSK example :

Values to code	with BPSK (absolute)	with Differential BPSK (relative)
		starts with phase = 0
1	- 90 °	+ 180 °
0	90 °	+ 0 °

5). 8-PSK :

- 8 nodes and each gets separated
- 3 bits per symbol



6). QAM

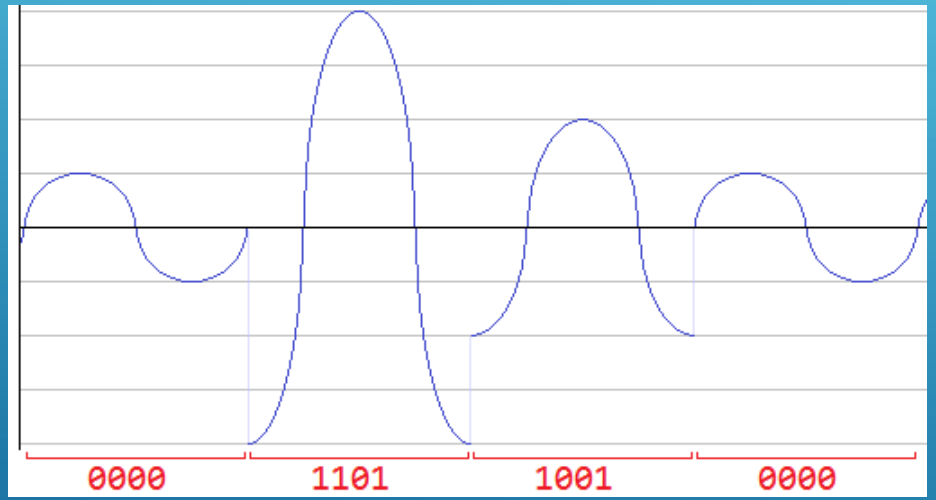
- Phase modulation
- Amplitude modulation

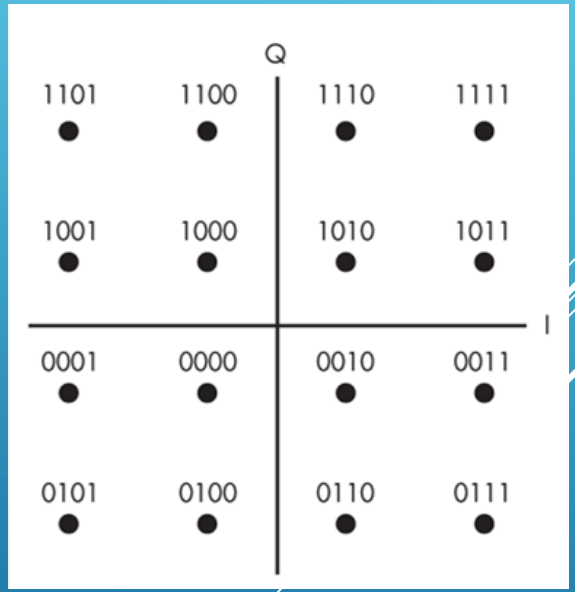
Quadrature Amplitude Modulation

Tools :
Constellation diagrams

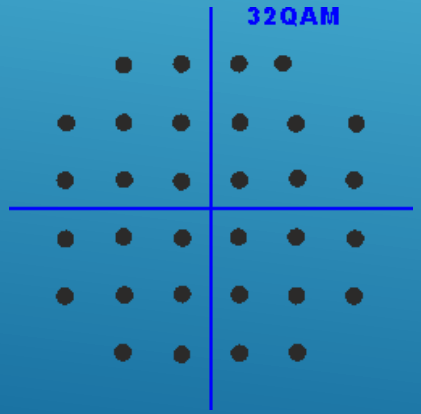
- representation of the modulated signal
- the symbols are represented as complex numbers, so they can be visualized as points on the complex plane
- the real axis is called the in phase axis or I-axis
- the imaginary axis is called the quadrature axis or Q-axis
- the points on a constellation diagram are called constellation points

QAM also changes amplitude not just phase… Example !





16 QAM



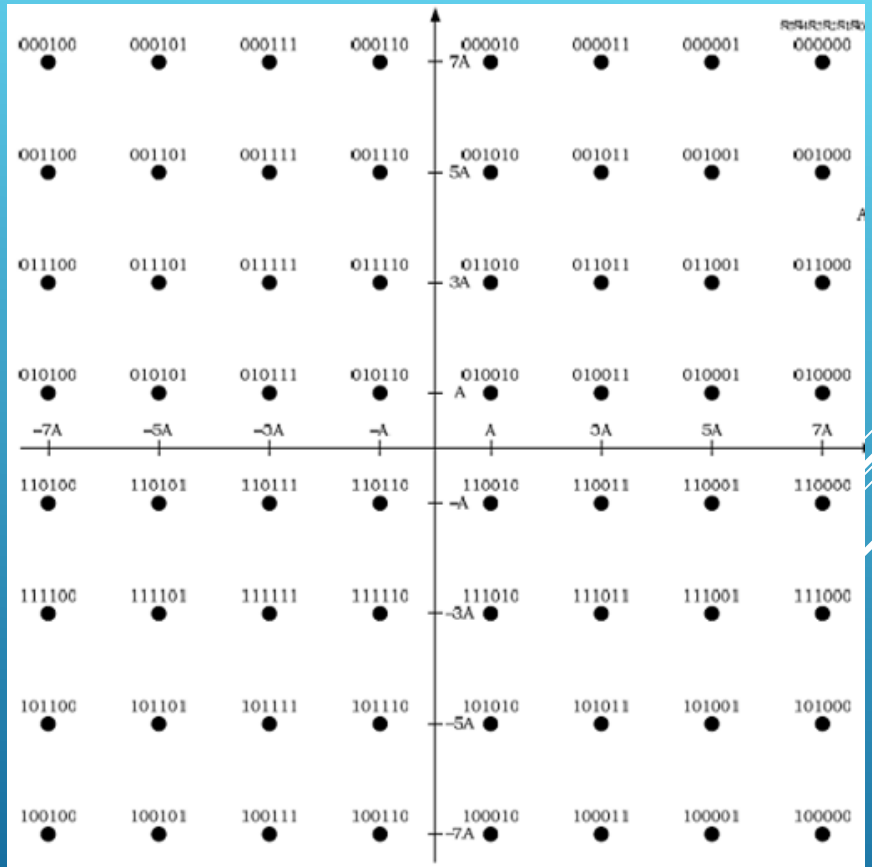


Figure 2.6.7.4-1. Signal Constellation for 64-QAM Modulation

7). MSK (Minimum Shift Keying) :

- Reduce interference caused by sharp transitions by filtering the signal
- Another better version on MSK is GMSK (Gaussian MSK)

ADVANTAGES OF GMSK

better spectral efficiency compared to other phase shift keyed modes

none of the information is carried as amplitude variations

⇒ more resilient to noise than some other forms of modulation because most noise is mainly amplitude based

APPLICATIONS OF GMSK

Numbers of radio communications applications

The most widely used is the GSM cellular technology which is used worldwide and has well over 3 billions subscribers

APPLICATIONS

broadcasting satelite uses QPSK and 8PSK

APPLICATION

Television

- digital cable channels are encoded and transmitted via the providers using QAM
- the QAM uses 6MHz bandwidth as ATSC standard
- uses 16 QAM and 64 QAM in UK, 64 QAM and 256 QAM in US

APPLICATION

Wireless LAN

- uses variety of PSKs depending on data rate required
- for IEEE 802.11b[1][2], at 1 Mbit/s, it uses DBPSK. At 2 Mbit/s, DQPSK is used. And at 5.5 Mbit/s and 11 Mbit/s, QPSK is used with more complex code keying
- for IEEE 802.11g[1][3], the LAN has 8 data rates which are 6, 9, 12, 18, 24, 36, 48 and 54 Mbit/s. The 6 and 9 Mbit/s modes use BPSK. The 12 and 18 Mbit/s modes use QPSK.
- The fastest four modes use forms of quadrature amplitude modulation.

APPLICATION

BLUETOOTH

Bluetooth uses a GMSK modulation. It uses 0.35 as its modulation index. In new bluetooth technology (BLE), it uses GMSK with 0.5 as modulation index. It has lower power consumption and increase range

ADVANTAGES AND DISADVANTAGES

Advantages

- Bandwidth is used more efficient
- Less susceptible to errors and noise
- No bandwidth limitation

Disadvantages

- Ambiguity of output signal
- Need complicated sync circuit at receiver

JUST IN CASE, INTERESTING LINKS

About QAM : http://www.radio-electronics.com/info/rf-technology-design/quadrature-amplitude-modulation-qam/what-is-qam-tutorial.php

QAM formulas : http://www.radio-electronics.com/info/rf-technology-design/quadrature-amplitude-modulation-qam/theory-equations.php

VIDEOS

https://www.youtube.com/watch?v=931z7fvPhpk (time)

https://www.youtube.com/watch?v=d7I5NbFfBiU o