Redes Inalambricas

Capítulo I: Comunicaciones inalámbricas

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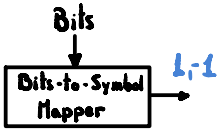
Universidad Nacional de San Agustín
Arequipa - Perú

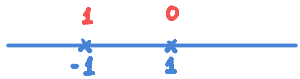
Septiembre, 2023

Sistemas de comunicaciones inalámbricos



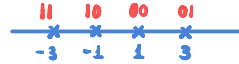
Mapper: Mapeo de bit a simbol

BPSK: 1 bit/symbol.



(Banda Base)

4 PAM: 2 bits/simbol



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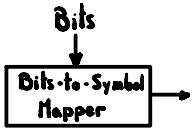
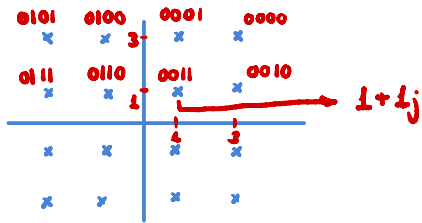


Mapper: Mapeo de bit a simbol

16-QAM
4 bits/symbol

Simbolos Complejos!!



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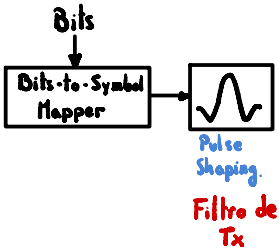
Pulse Shaping: Crea una señal digital suave



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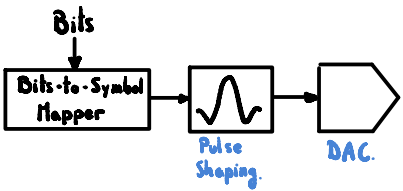

DAC: Toma los valores digitales y los transforma en una señal analogica.

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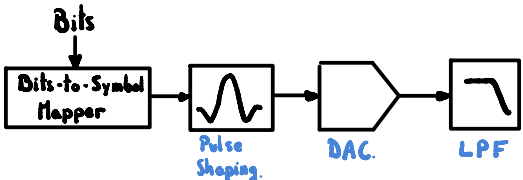
LPF: Filtro pasa bajas
Remueve las altos frecuencias.



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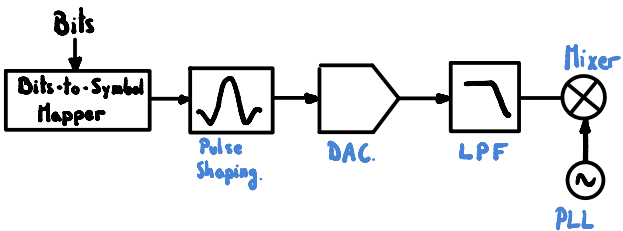

Mixer/PLL: Mueve el espectro de la señal a una frecuencia de operación

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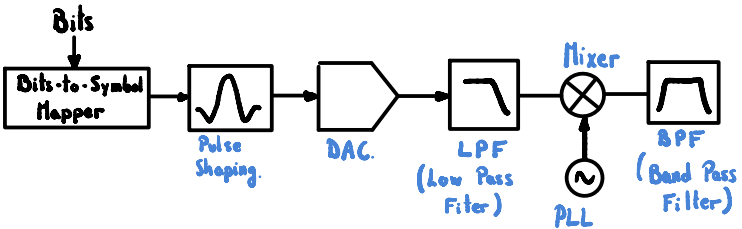
BPF: Filtro pasa-banda
Remueve frecuencias fuera de la frecuencia de operación.



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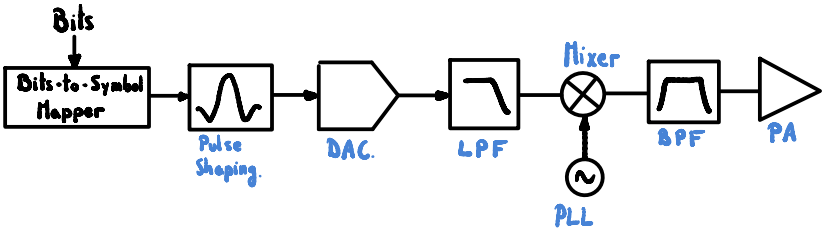
PA: Power Amplifier
Amplifica la señal.



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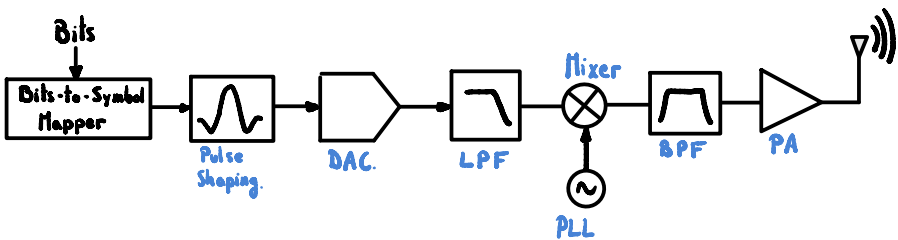

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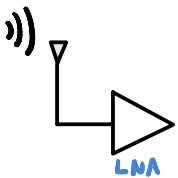
LNA: Low Noise Amplifier
Amplifica la señal con poco ruido.



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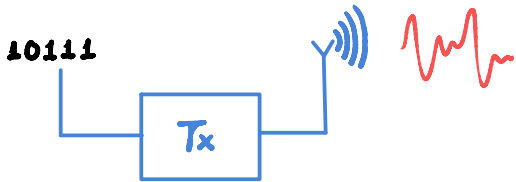
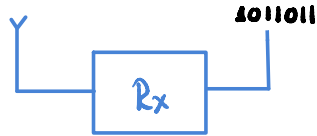
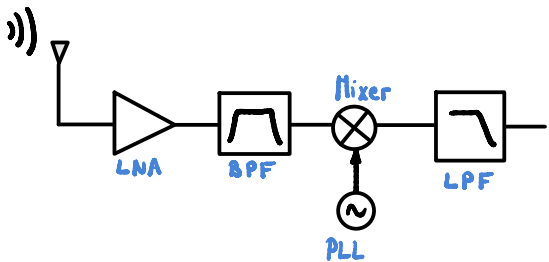




Mueve el espectro a la frecuencia base.



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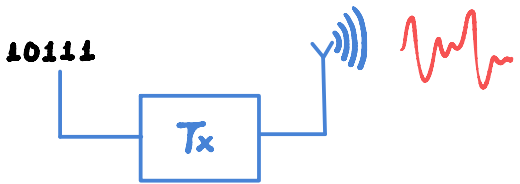

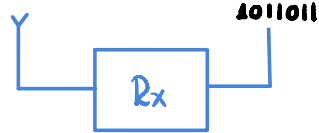

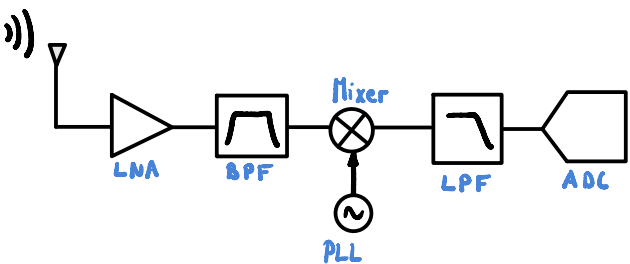

ADC: Toma la señal analogica y la digitaliza.

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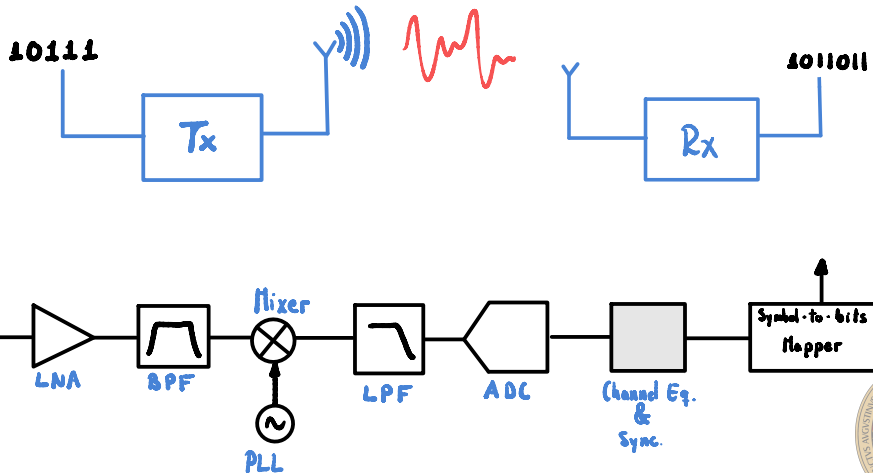

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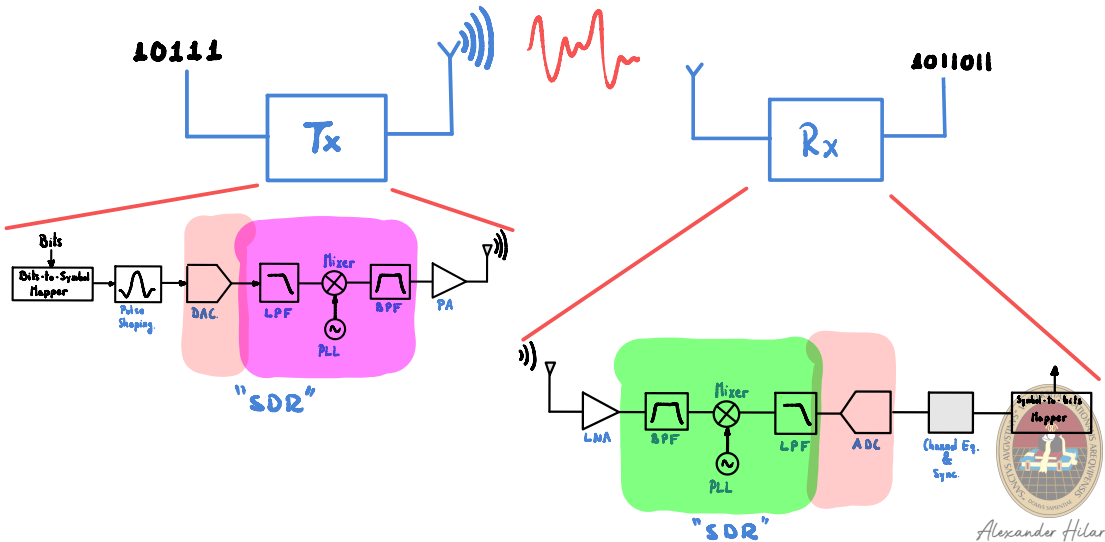

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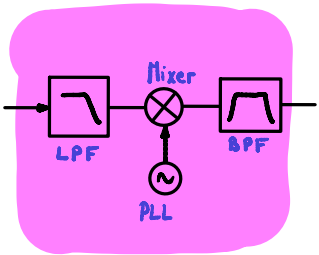
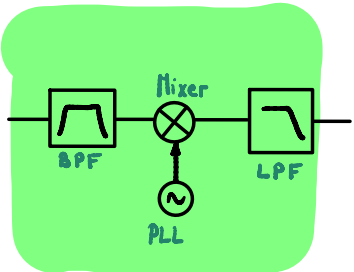
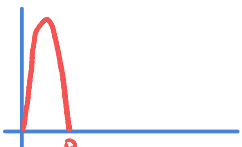
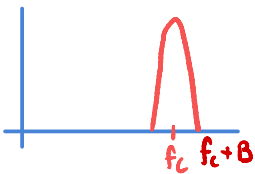
Subida/bajada en frecuencia









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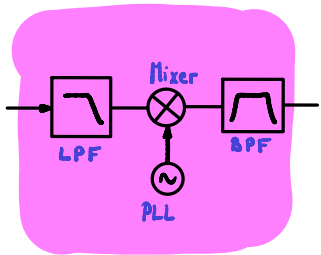

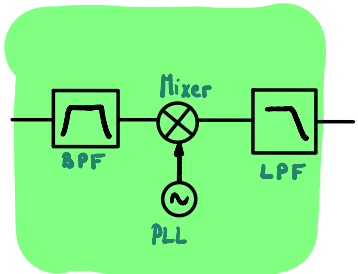

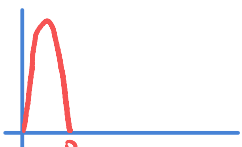

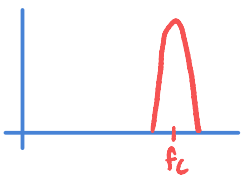

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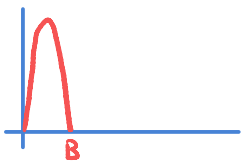
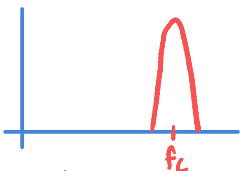
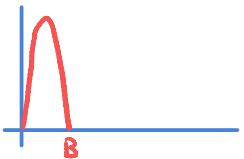




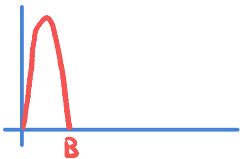


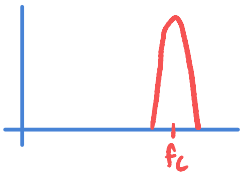
Porque no transmitimos todo a baja frecuencia?

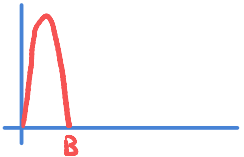
- No hay suficiente ancho de banda { Velocidad de Tx / Diferentes tecnologías }

- Tamaño de la antena $\propto$ longitud de onda.

Subida/bajada en frecuencia





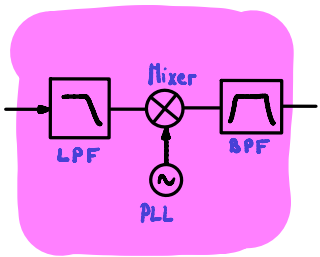


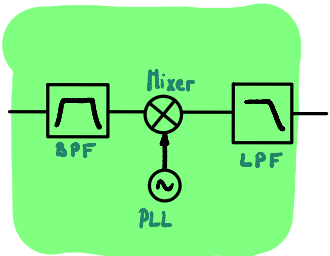
Porque necesitamos subir y bajar en la frecuencia?

- Porque no se puede transmitir todo a baja frecuencia
- Porque no transmitimos & recibimos todo a altas frecuencias?

Nyquist.

Subida/bajada en frecuencia



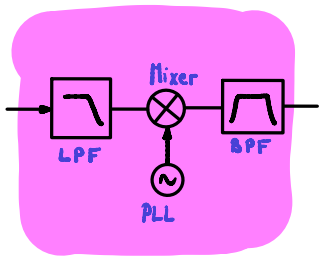


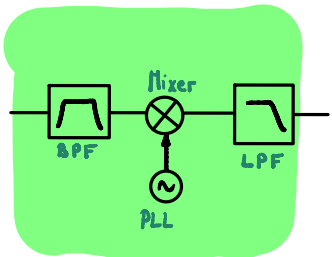
$s(t)$ — $\times$ — $s(t)\cos(2\pi f_c t)$ — $\times$ — $s(t)\cos^2(2\pi f_c t)$

$\cos(2\pi f_c t)$ $\qquad$ $\cos(2\pi f_c t)$

$\frac{1}{2} + \frac{1}{2}\cos(2\pi 2 f_c t)$

Subida/bajada en frecuencia





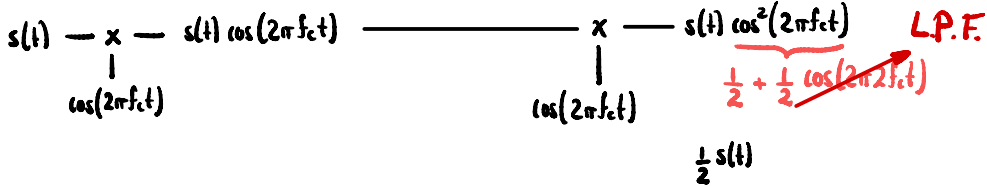
$s(t)$ — x — $s(t)\cos(2\pi f_c t)$ — x — $s(t)\cos^2(2\pi f_c t)$

$\cos(2\pi f_c t)$ $\cos(2\pi f_c t)$

$\frac{1}{2} + \frac{1}{2}\cos(2\pi 2 f_c t)$ → L.P.F.

$\frac{1}{2}s(t)$

Subida/bajada en frecuencia



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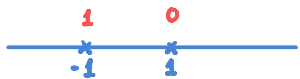
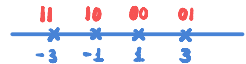
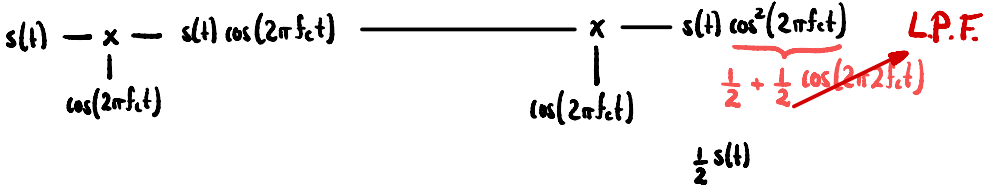


2 PAM: 2 bits/simbol



Subida/bajada en frecuencia



Mapper: Mapeo de bit a simbol

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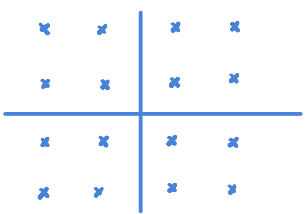
4 bits/symbol

Simbolos Complejos!!



s(t) es complejo.

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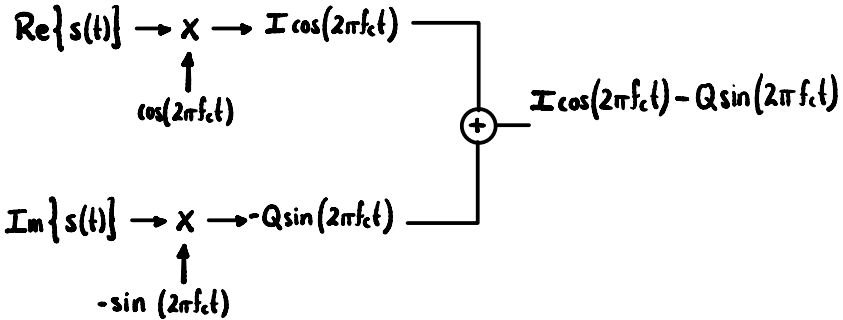
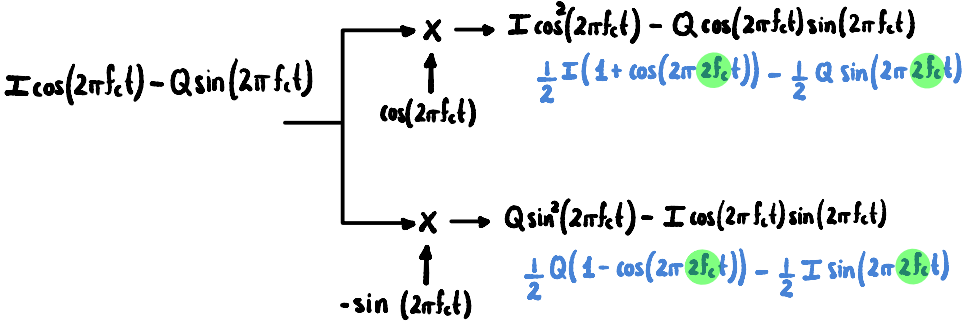
Subida en frecuencia



Bajada en frecuencia



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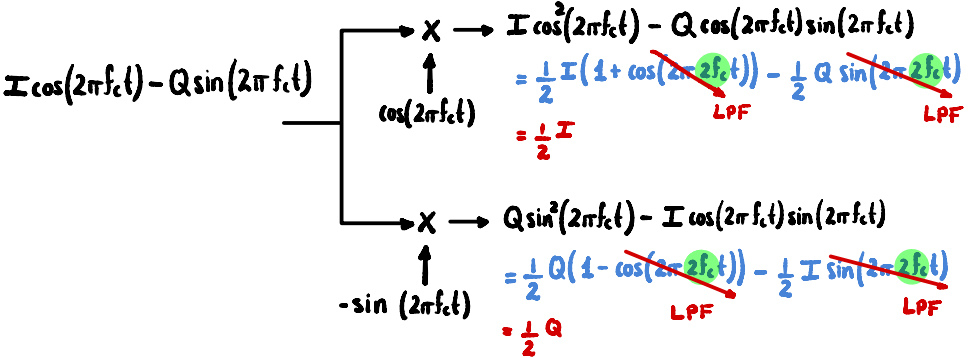
Bajada en frecuencia



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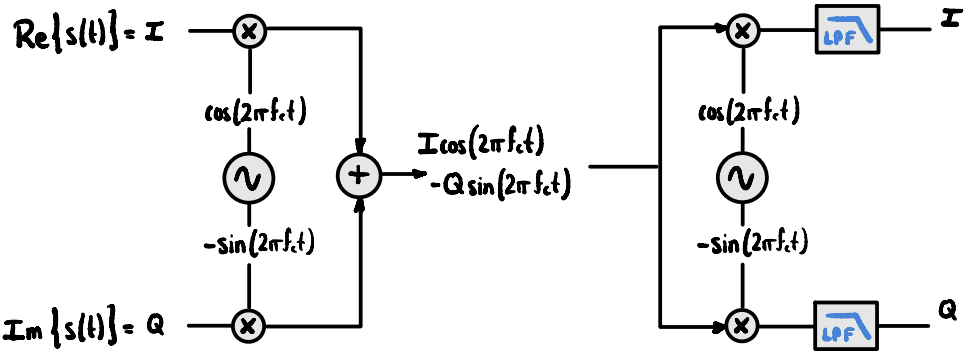

$$s(t) \times e^{j2\pi f_c t} \rightarrow Re\{s(t)\, e^{j2\pi f_c t}\} \rightarrow \times e^{-j2\pi f_c t} \rightarrow s(t)$$

$$e^{j2\pi f_c t} = \cos(2\pi f_c t) - j\sin(2\pi f_c t)$$

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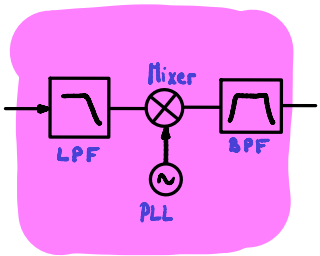
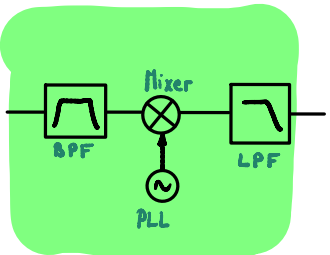
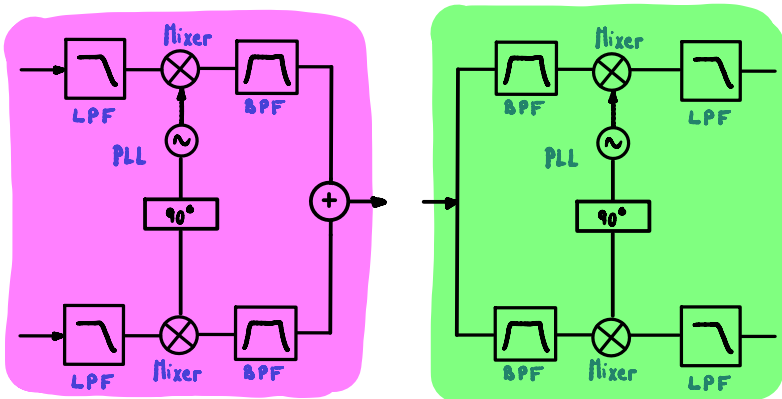
Subida/bajada en frecuencia





Subida/bajada en frecuencia



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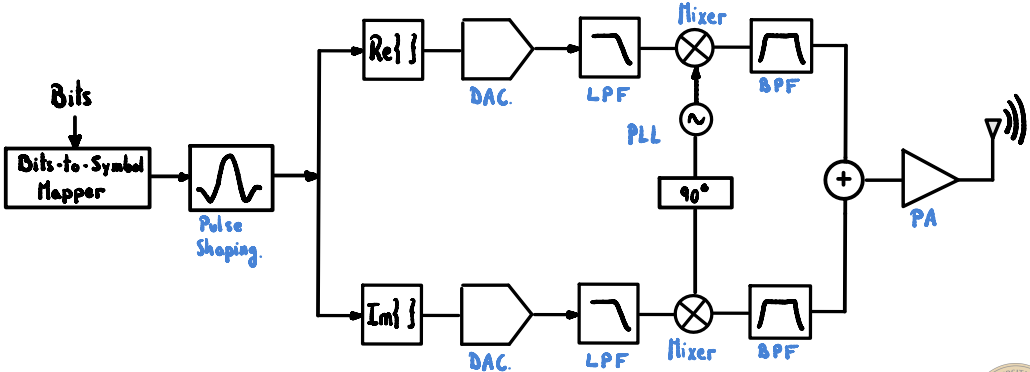
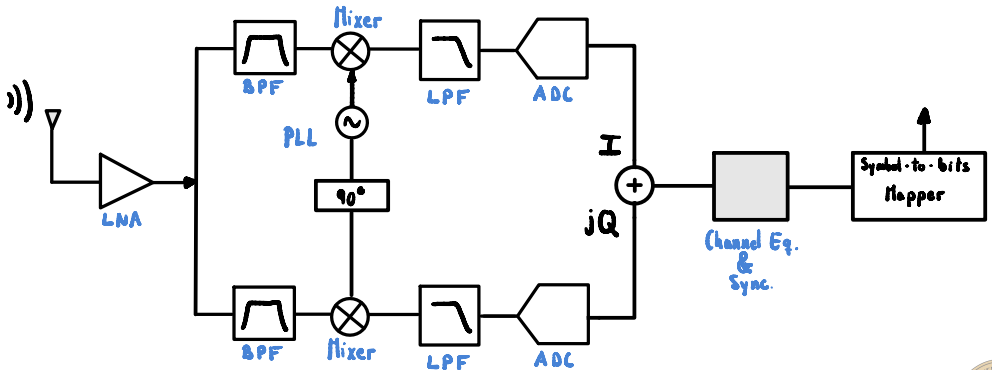
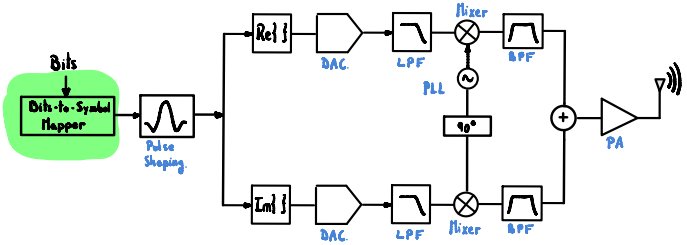
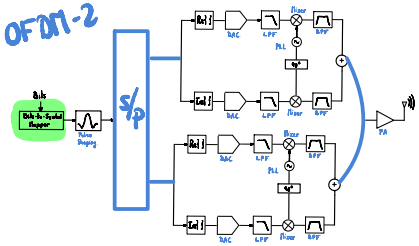


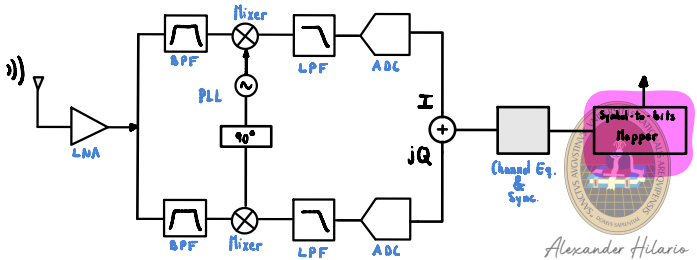
Sistemas de comunicaciones inalámbricas



Sistemas de comunicaciones inalámbricas







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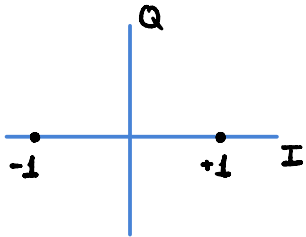
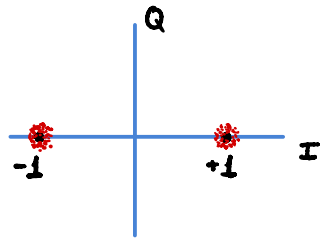
Modulación BPSK



$x(t)$

Constelación transmitida



$y(t) = x(t) + n(t)$

Constelación Recibida

$$x(t) = \sum_{k=-\infty}^{\infty} A_k \, g(t-kT) \cos(2\pi f_c t)$$

P.E. V.A.

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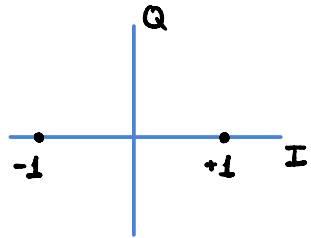
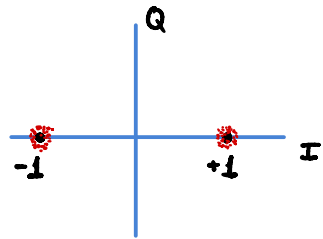
Modulación BPSK



$x(t)$

Constelación transmitida



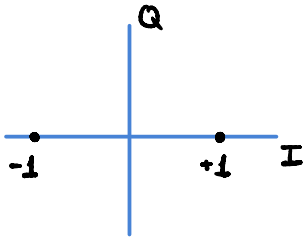
$y(t) = x(t) + n(t)$

Constelación Recibida

- La decodificación depende del SNR?

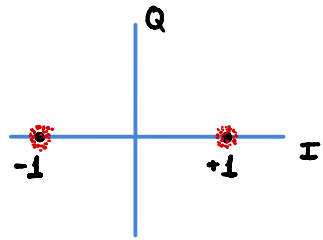
$$SNR = \frac{\text{Potencia de señal}}{\text{Potencia de ruido}} = \frac{E[x^2(t)]}{E[n^2(t)]} = \frac{E_s}{N_0}$$

Modulación BPSK



$x(t)$

Constelación transmitida

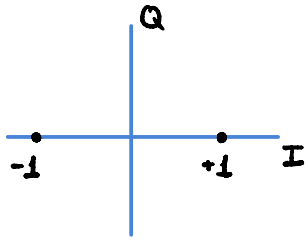


$y(t) = x(t) + n(t)$

Constelación Recibida

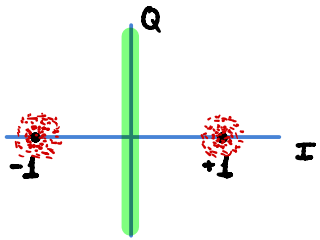
$$SNR = \frac{E_s}{N_0} = 25dB$$

Modulación BPSK



$x(t)$

Constelación transmitida

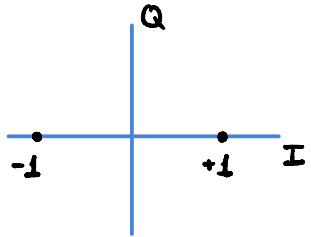


$y(t) = x(t) + n(t)$

Constelación Recibida

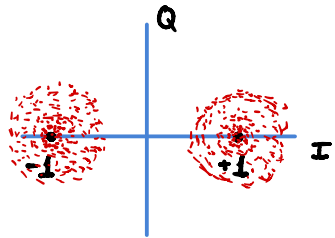
$$SNR = \frac{E_s}{N_0} = 19\ dB$$

Modulación BPSK



$x(t)$

Constelación transmitida



$y(t) = x(t) + n(t)$

Constelación Recibida

$$SNR = \frac{E_s}{N_0} = 13\ dB$$

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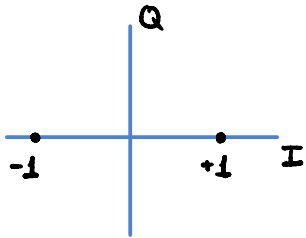
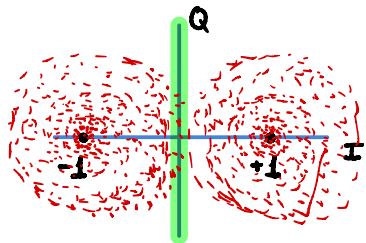
Modulación BPSK



$x(t)$

Constelación transmitida

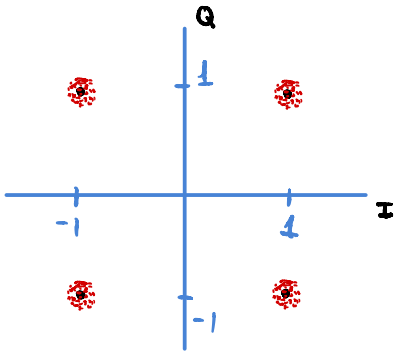


$y(t) = x(t) + n(t)$

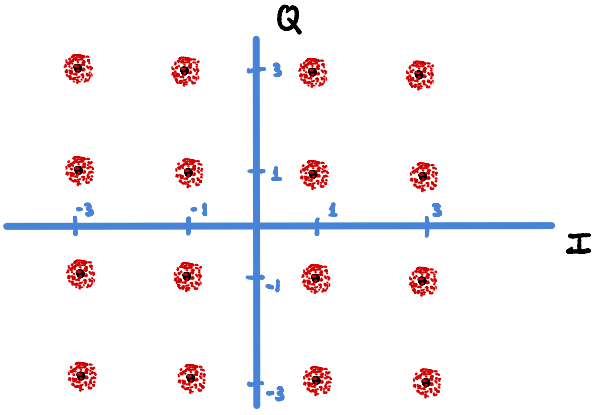
Constelación Recibida

$$SNR = \frac{E_s}{N_0} = 7 \text{ dB}$$

4-QAM

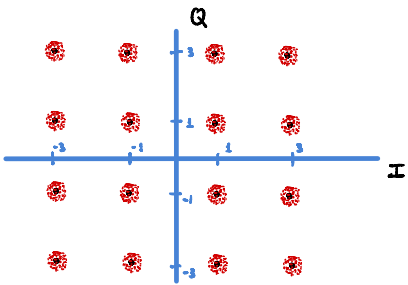


16-QAM

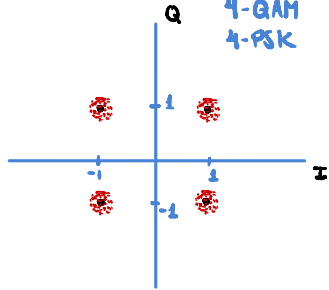


Modulaciones digitales

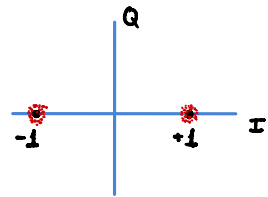
16-QAM



4-QAM
4-PSK

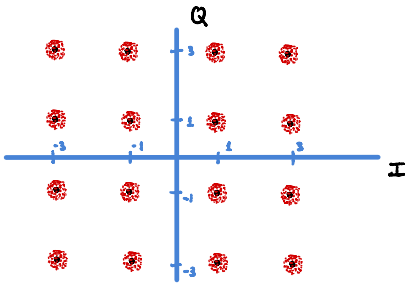


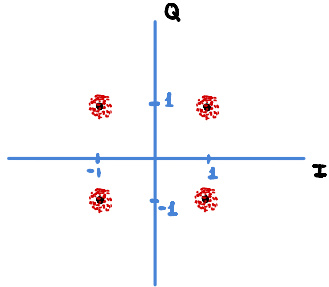
BPSK

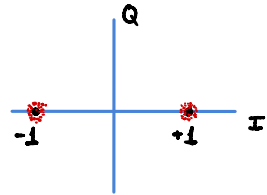


- Estas modulaciones tienen el mismo SNR?

Modulaciones digitales







- Estas modulaciones tienen el mismo SNR?

$$SNR = \frac{(4\times2 + 8\times10 + 4\times18)/16}{N_0}$$

$$SNR = \frac{10}{N_0}$$

$$SNR = \frac{(2\times4)/4}{N_0}$$

$$SNR = \frac{2}{N_0}$$

$$SNR = \frac{(2\times1)/2}{N_0}$$

$$SNR = \frac{1}{N_0}$$

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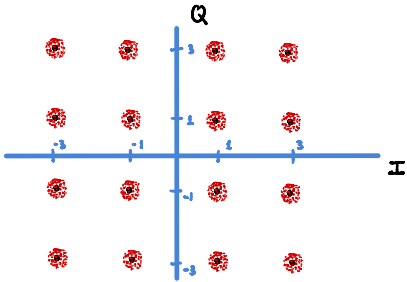
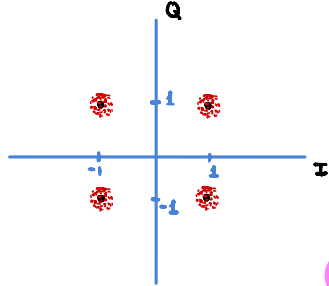
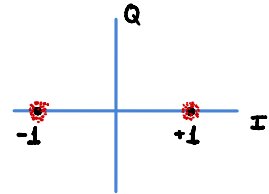
Modulaciones digitales







La potencia de transmisión no es la misma.

- Estas modulaciones tienen el mismo SNR?

$$SNR = \frac{(4\times2 + 8\times10 + 4\times18)/16}{N_0}$$

$$SNR = \frac{10}{N_0}$$

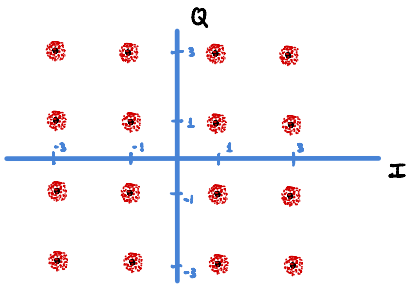
$$SNR = \frac{(2\times4)/4}{N_0}$$

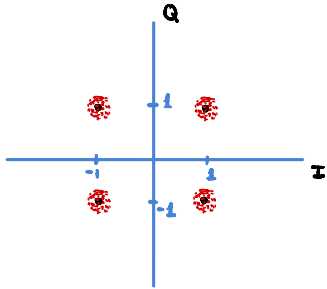
$$SNR = \frac{2}{N_0}$$

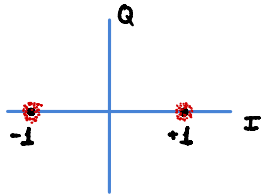
$$SNR = \frac{(2\times1)/2}{N_0}$$

$$SNR = \frac{1}{N_0}$$

Modulaciones digitales







- Estas modulaciones tienen el mismo SNR?

$$SNR = \frac{(4\times 2/10 + 8\times 10/10 + 4\times 18/10)/16}{N_0}$$

$$SNR = \frac{1}{N_0}$$

$$SNR = \frac{(2\times 4/2)/4}{N_0}$$

$$SNR = \frac{1}{N_0}$$

$$SNR = \frac{(2\times 1)/2}{N_0}$$

$$SNR = \frac{1}{N_0}$$

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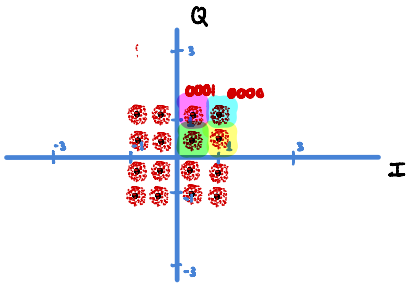
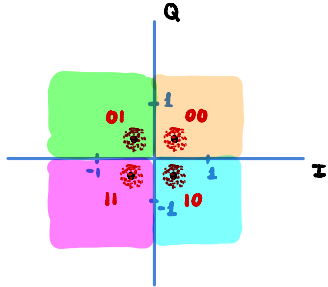
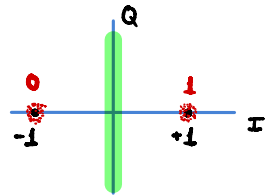
Modulaciones digitales







- Estas modulaciones tienen el mismo SNR?

$$SNR = \frac{(4\times 2/10 + 8\times 10/10 + 4\times 18/10)/16}{N_0}$$

$$SNR = \frac{1}{N_0}$$

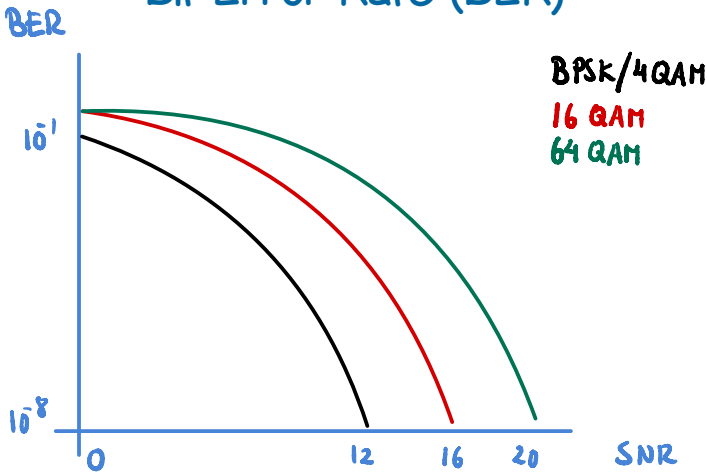
$$SNR = \frac{(2\times 1/2)/4}{N_0}$$

$$SNR = \frac{1}{N_0}$$

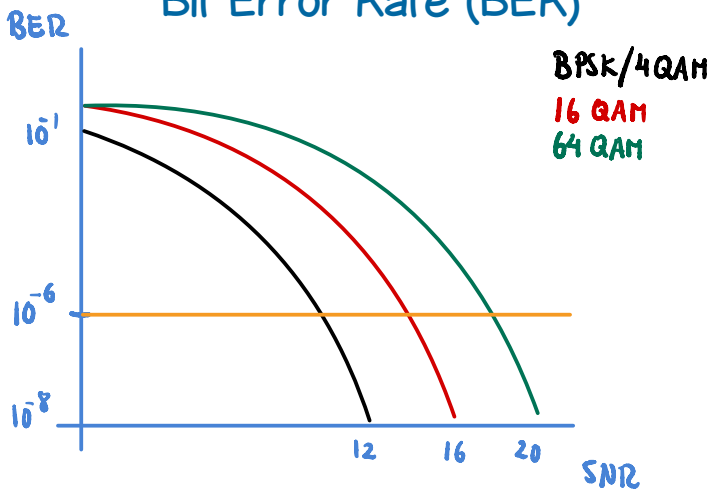
$$SNR = \frac{(2\times 1)/2}{N_0}$$

$$SNR = \frac{1}{N_0}$$

Bit Error Rate (BER)



Bit Error Rate (BER)



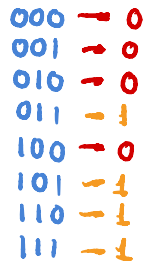
Detección de errores

- Agrega bits redundantes para detectar errores en el receptor
- Checksums
  - Detector de paridad
  - CRC: Comprobación de redundancia cíclica
  - Tasa de codificación: Data Bits/Coded Bits
- Si el paquete falla la prueba de checksum
  - El paquete es descartado
  - Paquete perdido

Codificación: Forward Error Correction (FEC)

- Agrega bits redundantes para corregir errores en el receptor

- FEC: Forward Error Correction
  - Repetición



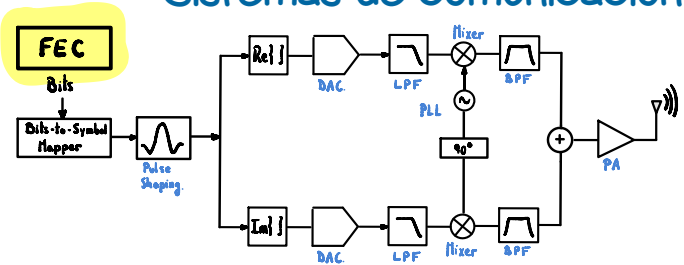
  - Códigos convolucionales
  - Códigos Turbo
  - Códigos Polares
  - Códigos LDPC

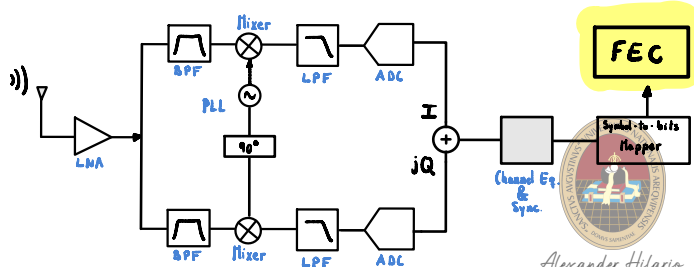
tarea

por si tengo tiempo

- Tasa de código: Nro de bits sin codificar sobre Nro de bits codificado

Sistemas de comunicaciones inalámbricas





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Tasa de transmisión inálambrica

- Tasa de transmisión de datos
  - Ancho de banda: muestras/sec
  - Modulación: Bits/sample
  - Tasa de codificación: Data Bits/Coded Bits
- Capacidad de canal (canal con ruido)
  - Maxima tasa de datos alcanzable
  - Teorema de Shannon

$$C = B \log_2(1 + SNR)$$

↑ Codificación
↑ Hardware (MIMO)

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Redes Inalambricas

Capítulo I: Comunicaciones inalámbricas

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Universidad Nacional de San Agustín
Arequipa - Perú

Septiembre, 2023