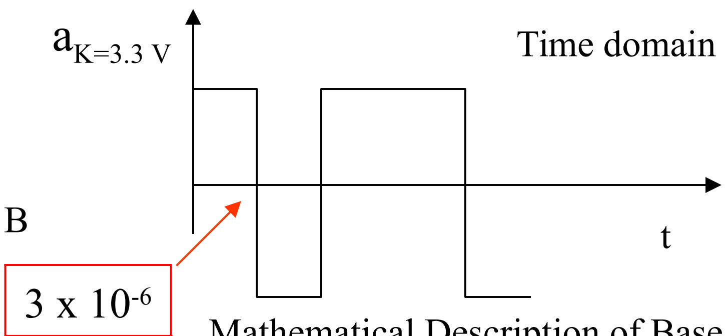
Base Band Signal

A

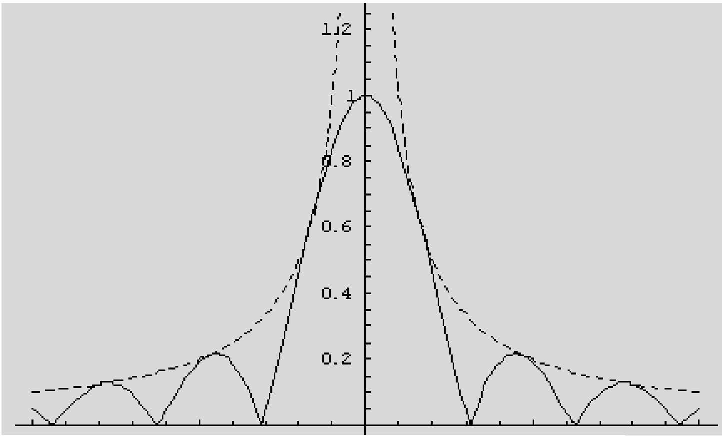
Definition: Signal transmitted near zero frequency range without frequency modulation.

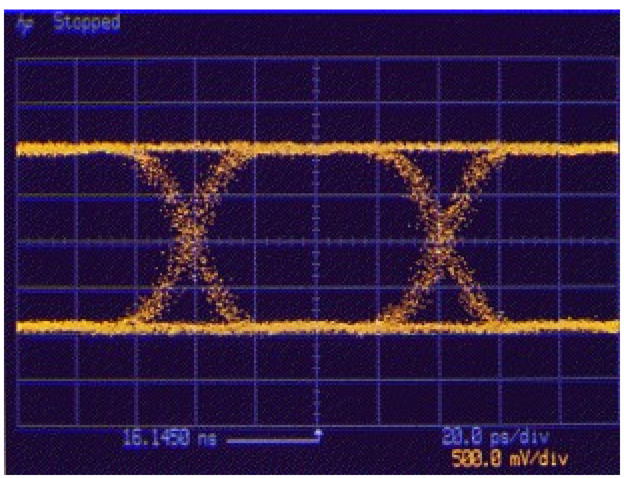
Time domain



Mathematical Description of Base Band Signal, see lecture notes.

Frequency domain





Eye Pattern: Characterization of Base Band Signal

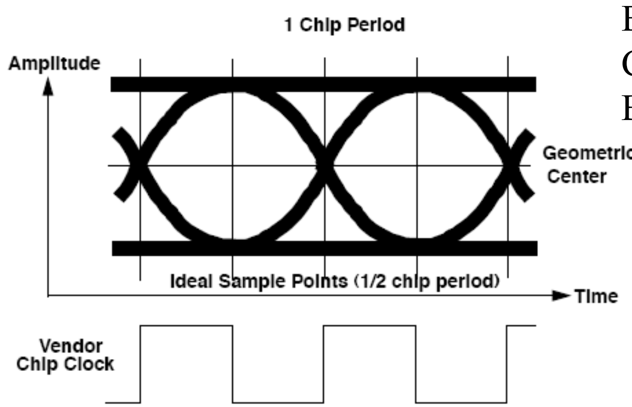
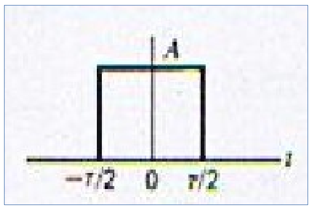


Figure 149—Chip clock alignment with baseband eye pattern

IEEE 802.11b Standard pp. 56

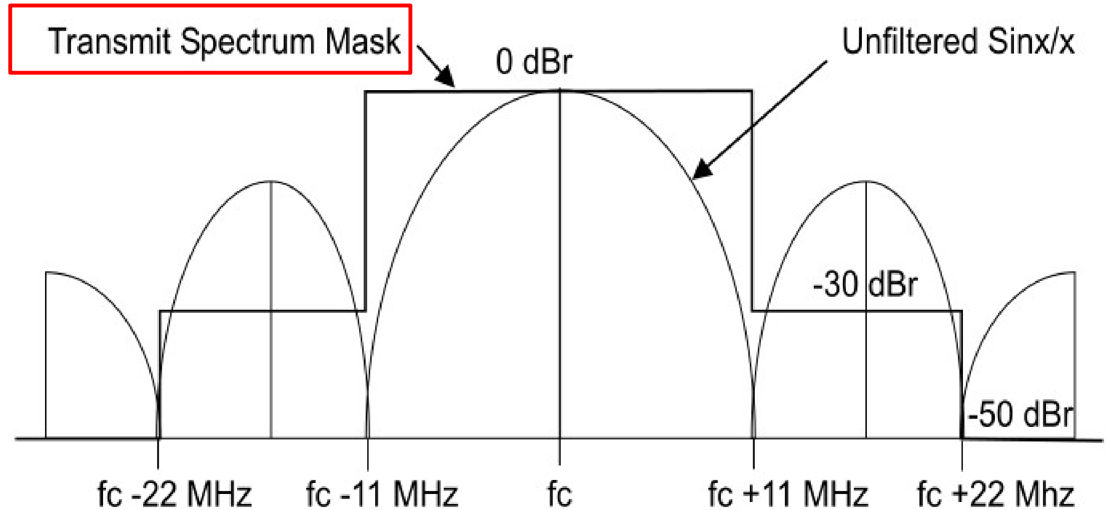
Base Band Signal Formulation

Time domain



$$g(t) = \begin{cases} A & \text{for} \quad [-T/2, T/2] \\ 0 & \text{otherwise} \end{cases} \qquad \text{...(1)}$$

$$\boxed{A\tau \frac{\sin \pi f \tau}{\pi f \tau}} \qquad \text{...(2)}$$



Frequency domain

Figure 145—Transmit spectrum mask from IEEE 802.11 b, pp. 60

Example: Calculation of bandwidth

Let equation (2) = 0, then we have

Pi * f * T = k * Pi

Let k=1 for the first pair of zero crossings, we have

$$f = 1/T$$

Counting both sides of the spectrum, we have

$$\boxed{BW = 2/T}$$

Bandwidth and Channels

Table 105—High Rate PHY frequency channel plan

CHNL_ID	Frequency (MHz)	X'10' FCC	X'20' IC	X'30' ETSI	X'31' Spain
1	2412	X	X	X	—
2	2417	X	X	X	—
3	2422	X	X	X	—
4	2427	X	X	X	—
5	2432	X	X	X	—
6	2437	X	X	X	—
7	2442	X	X	X	—
8	2447	X	X	X	—
9	2452	X	X	X	—
10	2457	X	X	X	X
11	2462	X	X	X	X
12	2467	—	—	X	—
13	2472	—	—	X	—
14	2484	—	—	—	—

IEEE 802.11b, pp. 49

Table 111—North American operating channels

Set	Number of channels	HR/DSSS channel numbers
1	3	1, 6, 11
2	6	1, 3, 5, 7, 9, 11

IEEE 802.11b, pp. 49

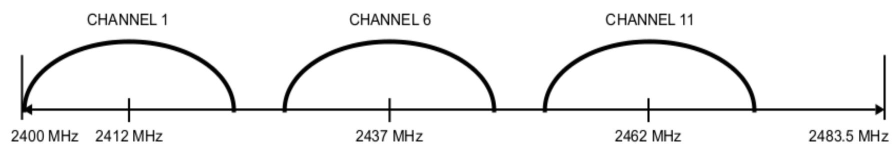


Figure 141—North American channel selection—non-overlapping

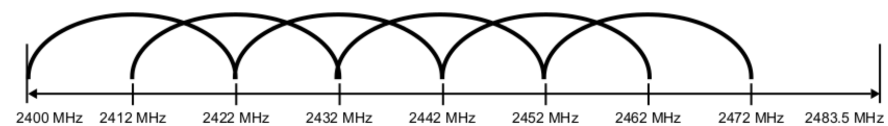


Figure 142—North American channel selection—overlapping

Example: find bandwidth, estimate bit rate

Eye Patterns of Base Band Signals

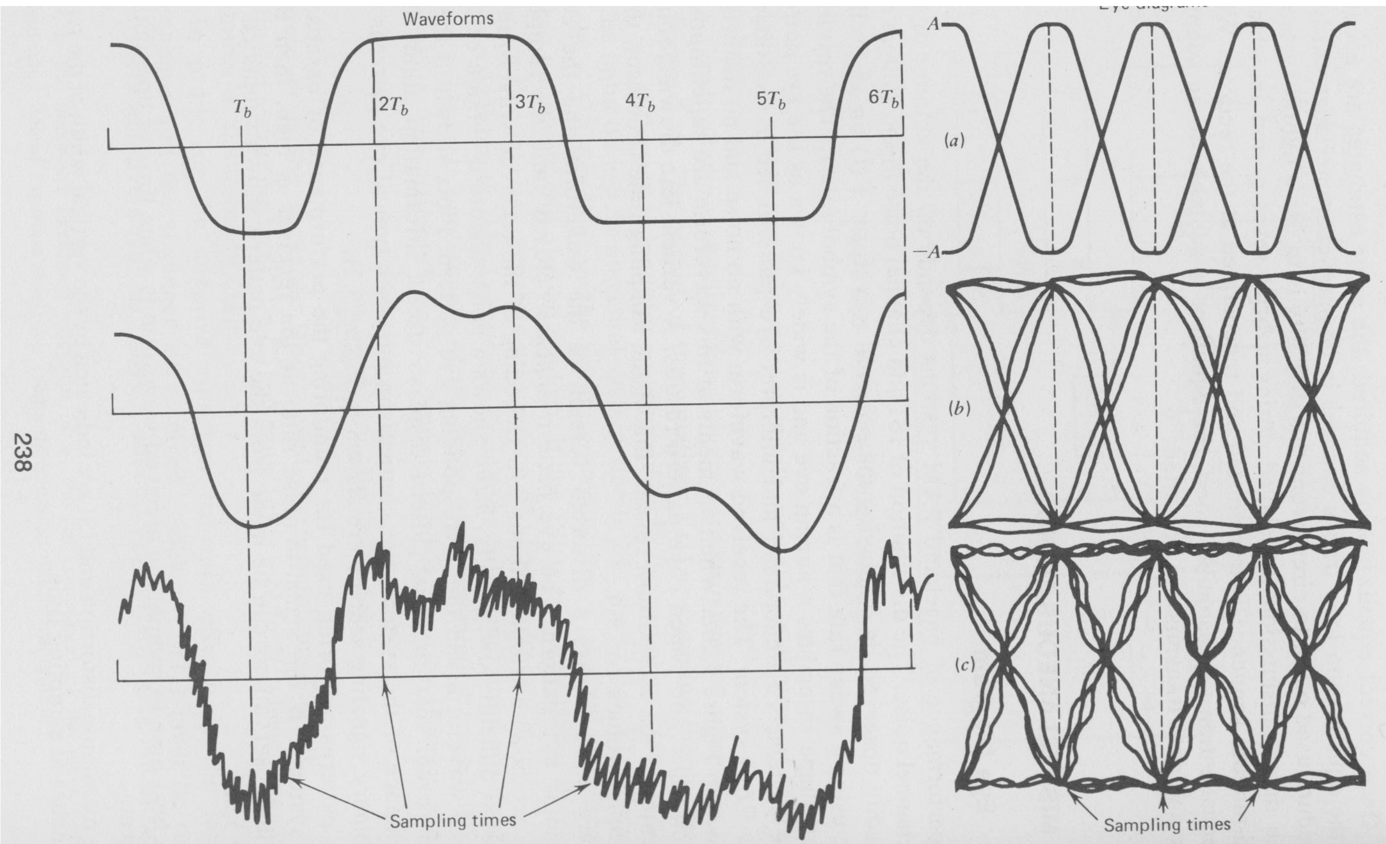
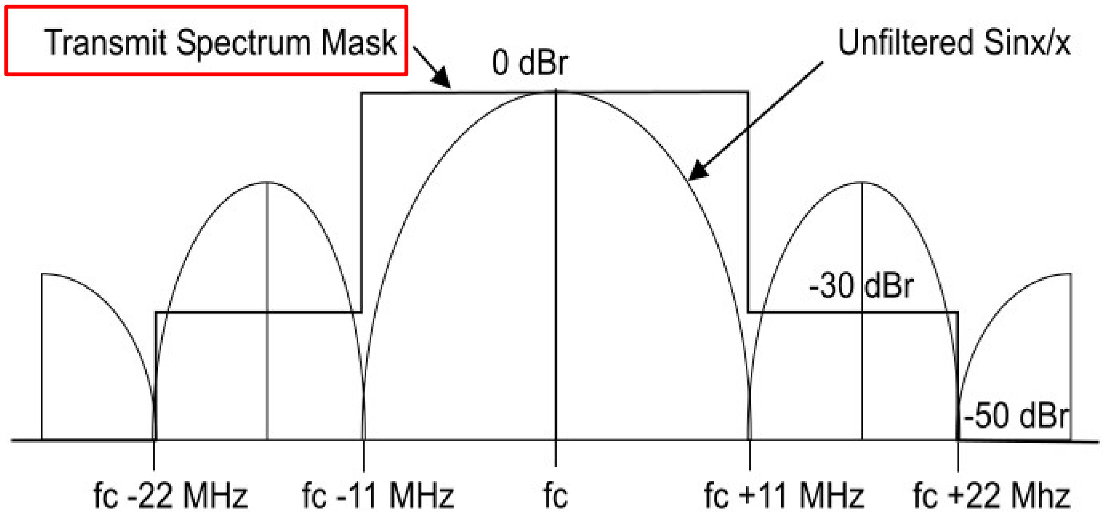


Figure 5.20 Eye diagrams of a binary PAM system. (*a*) Ideal. (*b*) Distorted. (*c*) Distortion + noise.

Reference: Digital and Analog Communication Systems, by K. Sam Shanmugam

Transmit Spectrum Mask



Frequency domain

Figure 145—Transmit spectrum mask
from IEEE 802.11 b, pp. 60

Example: Using DFT (Discrete Fourier Transform)
Design to analyzes transmit spectrum mask

$$\boxed{X_k = \sum_{n=0}^{N-1} x_n e^{-\frac{2\pi i}{N}kn} \qquad k = 0, \ldots, N-1}$$

$$\begin{bmatrix} \omega_N^{0\cdot 0} & \omega_N^{0\cdot 1} & \ldots & \omega_N^{0\cdot(N-1)} \\ \omega_N^{1\cdot 0} & \omega_N^{1\cdot 1} & \ldots & \omega_N^{1\cdot(N-1)} \\ \vdots & \vdots & \ddots & \vdots \\ \omega_N^{(N-1)\cdot 0} & \omega_N^{(N-1)\cdot 1} & \ldots & \omega_N^{(N-1)\cdot(N-1)} \end{bmatrix}$$

https://en.wikipedia.org/wiki/Discrete_Fourier_transform

Review

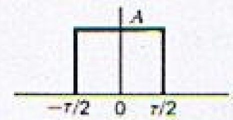
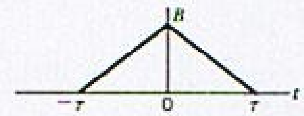
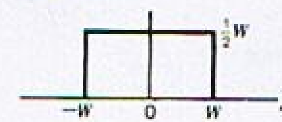
$$X(f) = \int_{-\infty}^{\infty} x(t) \exp(-j2\pi ft)\, dt$$

$$x(t) = \int_{-\infty}^{\infty} X(f) \exp(j2\pi ft)\, df$$

$$\int_{-\infty}^{\infty} |x(t)|^2\, dt = \int_{-\infty}^{\infty} |X(f)|^2\, df$$

Table C.1. Transform theorems.

Name of theorem	Signal	Fourier transform
(1) Superposition	$a_1x_1(t) + a_2x_2(t)$	$a_1X_1(f) + a_2X_2(f)$
(2) Time delay	$x(t - t_0)$	$X(f) \exp(-j2\pi ft_0)$
(3) Scale change	$x(at)$	$\|a\|^{-1}X(f/a)$
(4) Frequency translation	$x(t) \exp(j2\pi f_0t)$	$X(f - f_0)$
(5) Modulation	$x(t) \cos 2\pi f_0t$	$\frac{1}{2}X(f - f_0) + \frac{1}{2}X(f + f_0)$
(6) Differentiation	$\frac{d^nx(t)}{dt^n}$	$(j2\pi f)^nX(f)$
(7) Integration	$\int_{-\infty}^{t} x(t')\, dt'$	$(j2\pi f)^{-1}X(f) + \frac{1}{2}X(0)\delta(f)$
(8) Convolution	$\int_{-\infty}^{\infty} x_1(t - t')x_2(t')\, dt' = \int_{-\infty}^{\infty} x_1(t')x_2(t - t')\, dt'$	$X_1(f)X_2(f)$
(9) Multiplication	$x_1(t)x_2(t)$	$\int_{-\infty}^{\infty} X_1(f - f')X_2(f')\, df' = \int_{-\infty}^{\infty} X_1(f')X_2(f - f')\, df'$

	Signal	Fourier transform
(1)		$A\tau \frac{\sin \pi f\tau}{\pi f\tau} \triangleq A\tau \operatorname{sinc} f\tau$
(2)		$B\tau \frac{\sin^2 \pi f\tau}{(\pi f\tau)^2} \triangleq B\tau \operatorname{sinc}^2 f\tau$
(3)	$e^{-\alpha t}u(t)$	$\frac{1}{\alpha + j2\pi f}$
* (4)	$\exp(-\|t\|/\tau)$	$\frac{2\tau}{1 + (2\pi f\tau)^2}$
* (5)	$\exp[-\pi(t/\tau)^2]$	$\tau \exp[-\pi(f\tau)^2]$
* (6)	$\frac{\sin 2\pi Wt}{2\pi Wt} \triangleq \operatorname{sinc} 2Wt$	
(7)	$\exp[j(2\pi f_ct + \phi)]$	$\exp(j\phi)\delta(f - f_c)$
(8)	$\cos(2\pi f_ct + \phi)$	$\frac{1}{2}\delta(f - f_c)\exp(j\phi) + \frac{1}{2}\delta(f + f_c)\exp(-j\phi)$
(9)	$\delta(t - t_0)$	$\exp(-j2\pi ft_0)$
* (10)	$\sum_{m=-\infty}^{\infty} \delta(t - mT_s)$	$\frac{1}{T_s}\sum_{n=-\infty}^{\infty} \delta\left(f - \frac{n}{T_s}\right)$
* (11)	$\operatorname{sgn} t = \begin{cases}+1, & t > 0 \\ -1, & t < 0\end{cases}$	$-\frac{j}{\pi f}$
(12)	$u(t) = \begin{cases}1, & t > 0 \\ 0, & t < 0\end{cases}$	$\frac{1}{2}\delta(f) + \frac{1}{j2\pi f}$

From Digital and Analog Communications, By S. Shanmugam, John Weiley and Sons

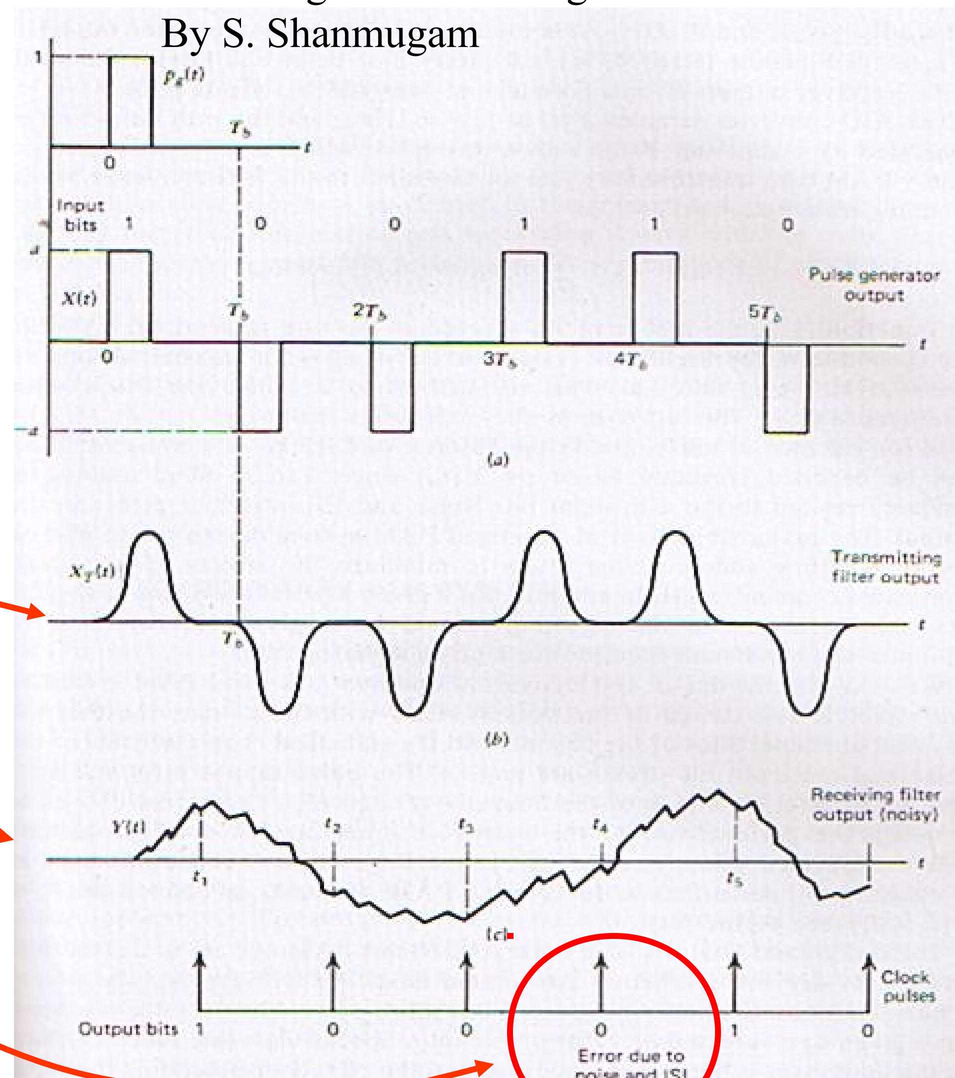
Based Band Signal w/o Modulation

From Digital and Analog Communications
By S. Shanmugam

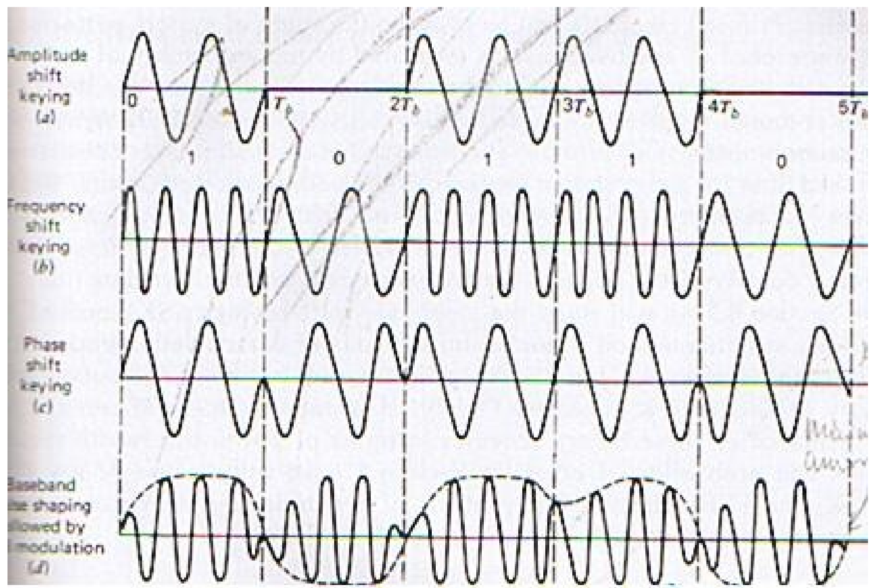
Transmitting Filter Output

Receiving Filter Output

Error



ASK, FSK, PSK



ASK

FSK

PSK

Base Band Shaping + Analog Modulation (DSB)