

# **Expressions to obtain the power spectral density (PSD) of basic binary pulse-shaping techniques**

EE161: Digital Communication Systems

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# PSD of three mappings

- Polar:

$$S_s(f) = \frac{a^2}{T_b} |G(f)|^2$$

- Unipolar:

$$S_s(f) = \frac{a^2}{4T_b} |G(f)|^2 \left[ 1 + \frac{1}{T_b} \sum_{n=-\infty}^{\infty} \delta \left( f - \frac{n}{T_b} \right) \right]$$

- AMI:

$$S_s(f) = \frac{a^2}{T_b} |G(f)|^2 \sin^2(\pi f T_b)$$

# Fourier transforms of three pulses

- NRZ:

$$|G(f)| = T_b |\text{sinc}(fT_b)|$$

- RZ:

$$|G(f)| = \frac{T_b}{2} \left| \text{sinc}\left(f \frac{T_b}{2}\right) \right|$$

- Manchester:

$$|G(f)| = T_b \left| \text{sinc}\left(f \frac{T_b}{2}\right) \right| \left| \sin\left(\pi f \frac{T_b}{2}\right) \right|$$

# Example

## PSD of *unipolar RZ* signaling

- Unipolar:

$$S_s(f) = \frac{a^2}{4T_b} |G(f)|^2 \left[ 1 + \frac{1}{T_b} \sum_{n=-\infty}^{\infty} \delta \left( f - \frac{n}{T_b} \right) \right]$$

- RZ pulse:

$$|G(f)| = \frac{T_b}{2} \left| \text{sinc} \left( f \frac{T_b}{2} \right) \right|$$

# Graphical sketch

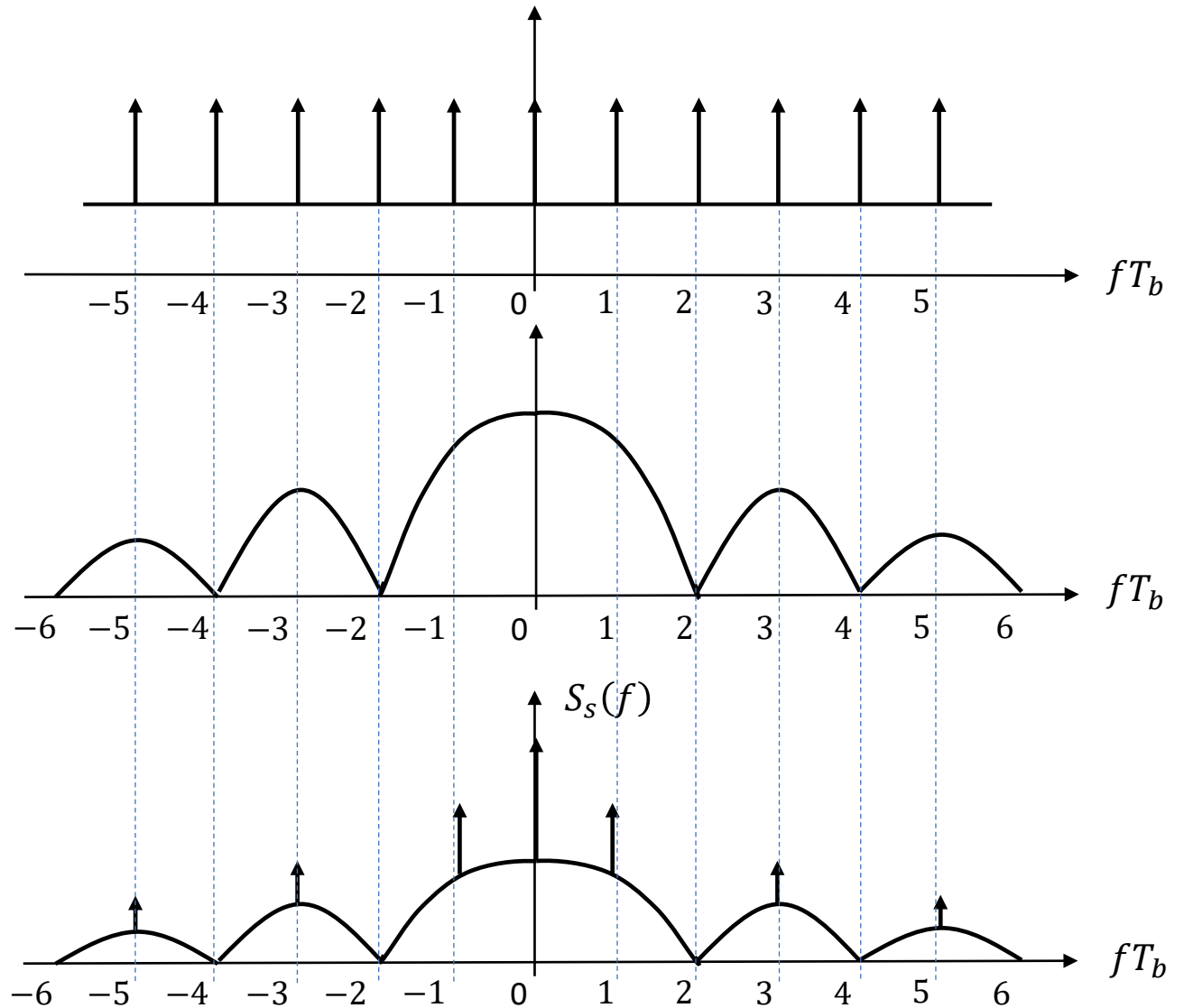
$$\frac{a^2}{4T_b} \left[ 1 + \frac{1}{T_b} \sum_{n=-\infty}^{\infty} \delta\left(f - \frac{n}{T_b}\right) \right]$$

$$|G(f)| = \frac{T_b}{2} \left| \text{sinc}\left(f \frac{T_b}{2}\right) \right|$$

$$S_s(f) = \frac{a^2}{4T_b} |G(f)|^2 \left[ 1 + \frac{1}{T_b} \sum_{n=-\infty}^{\infty} \delta\left(f - \frac{n}{T_b}\right) \right]$$

X

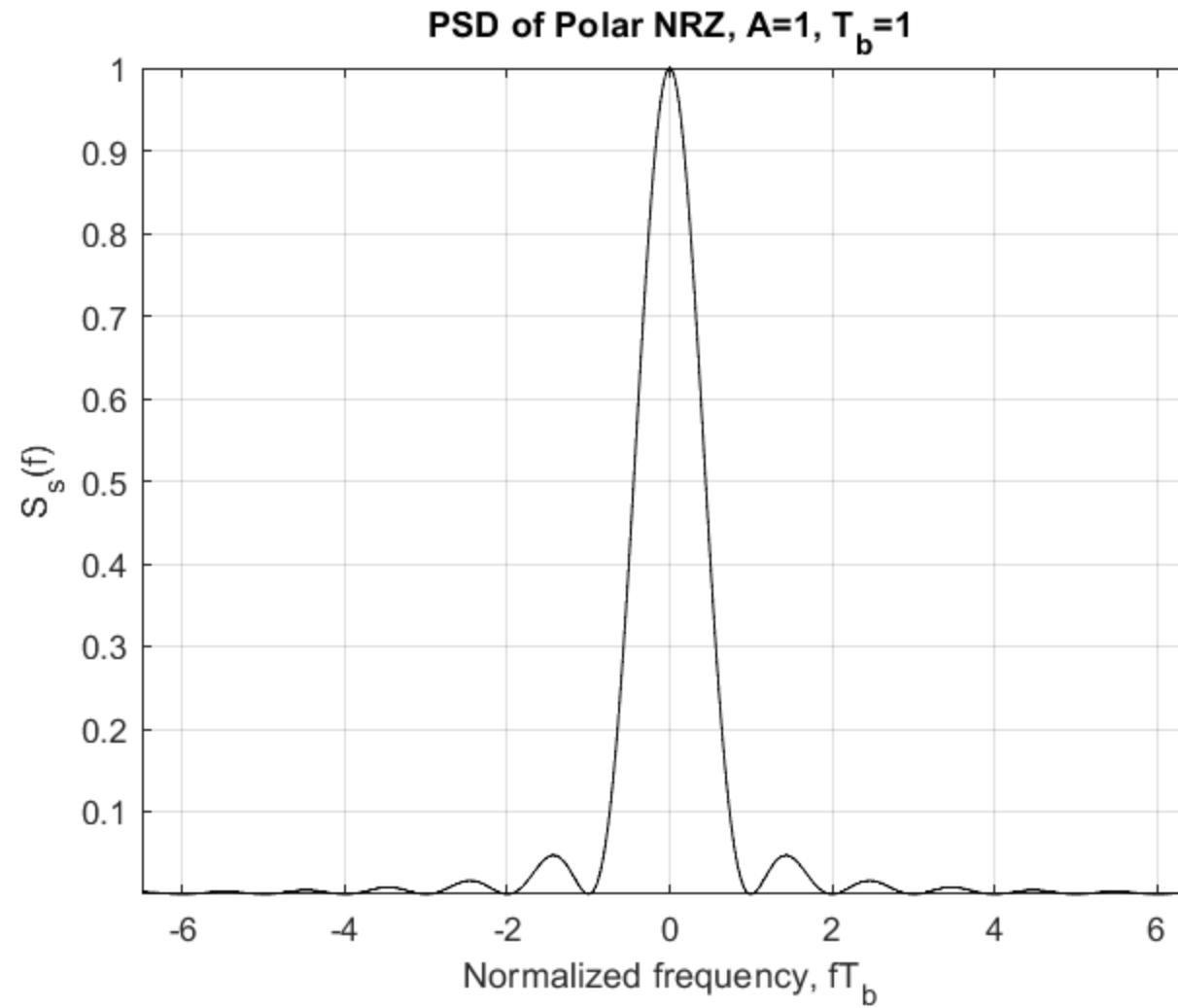
=



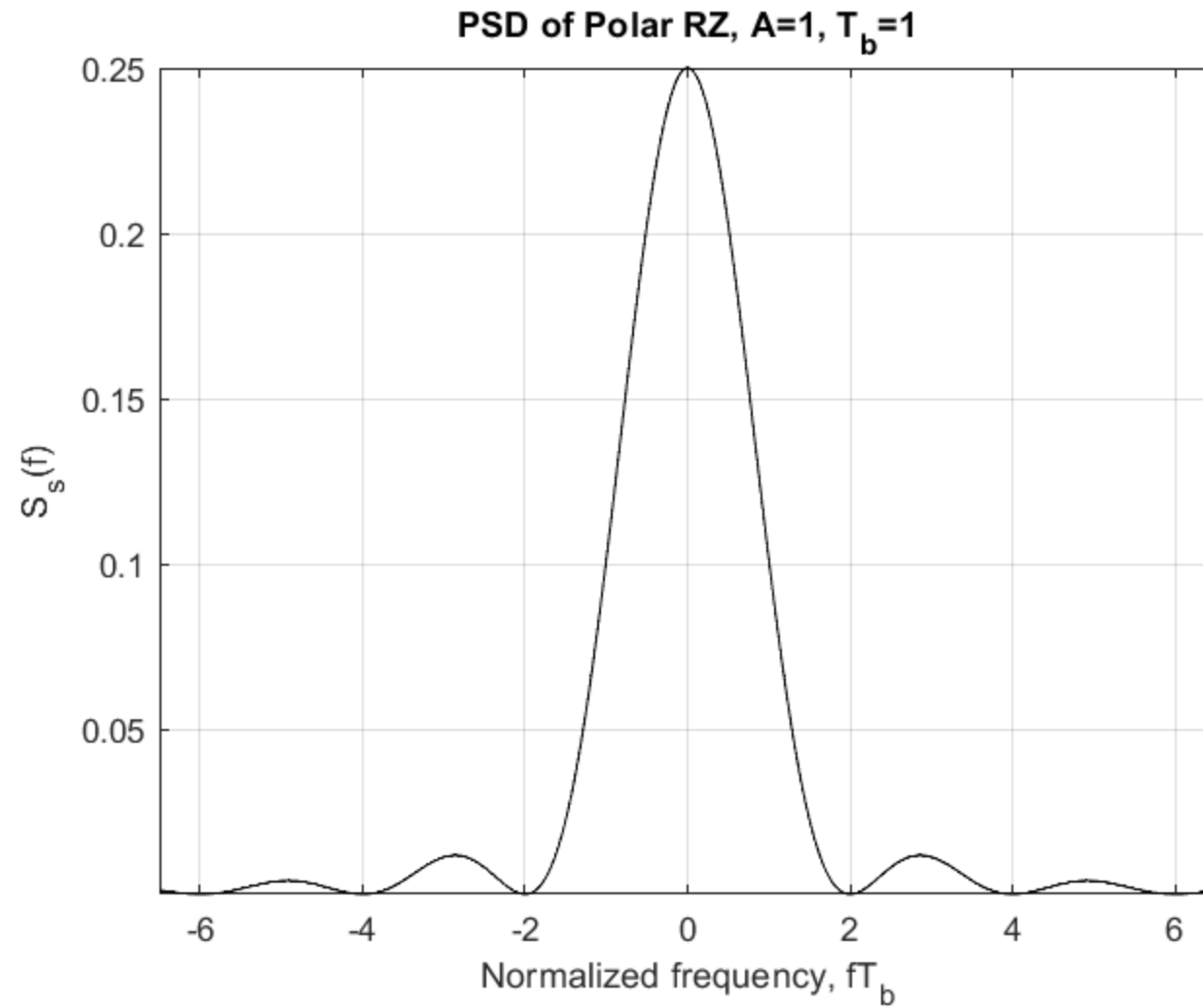
# MATLAB plots\*

\* Script “plot\_PSDs.m”

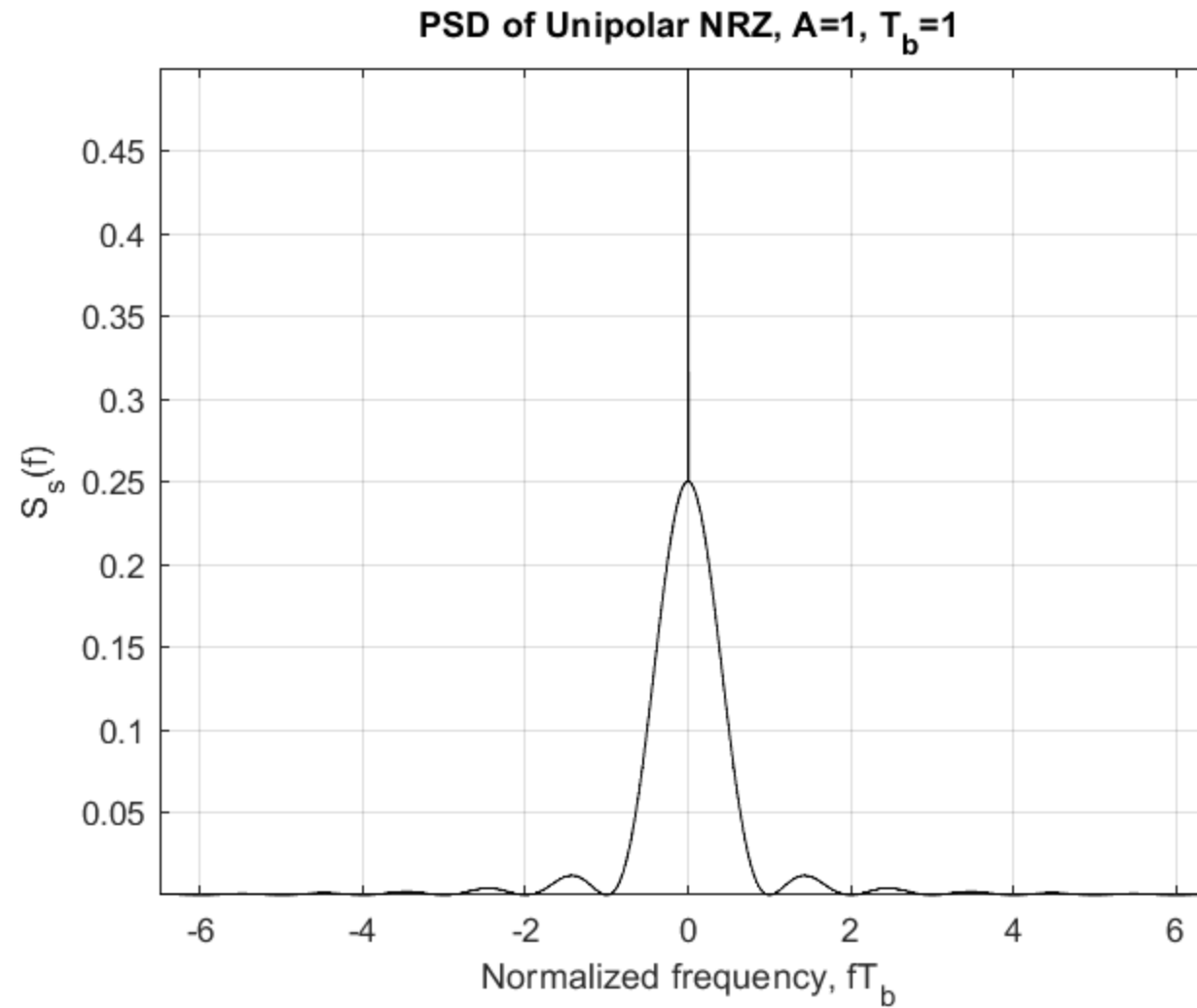
# Polar NRZ



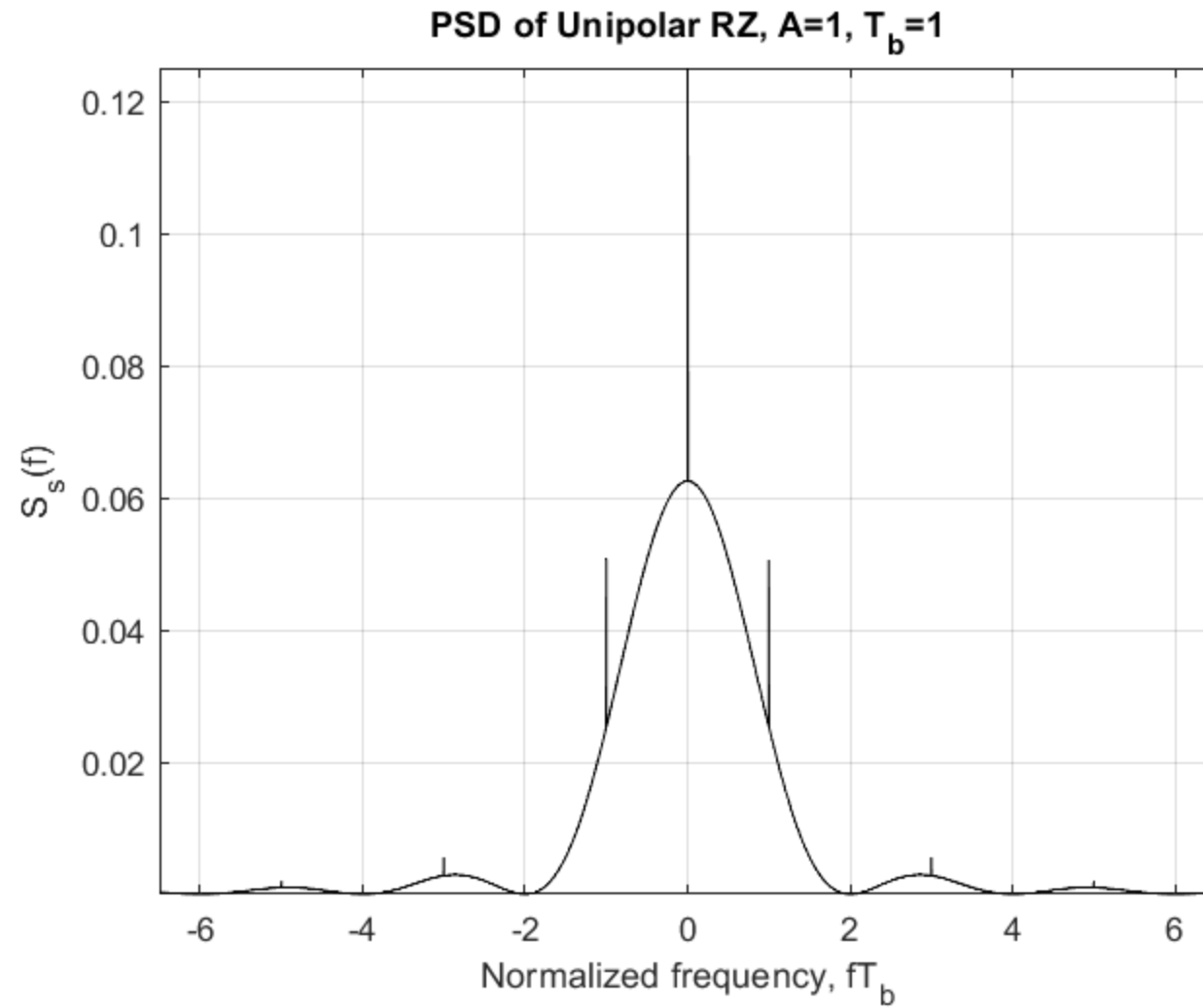
# Polar RZ



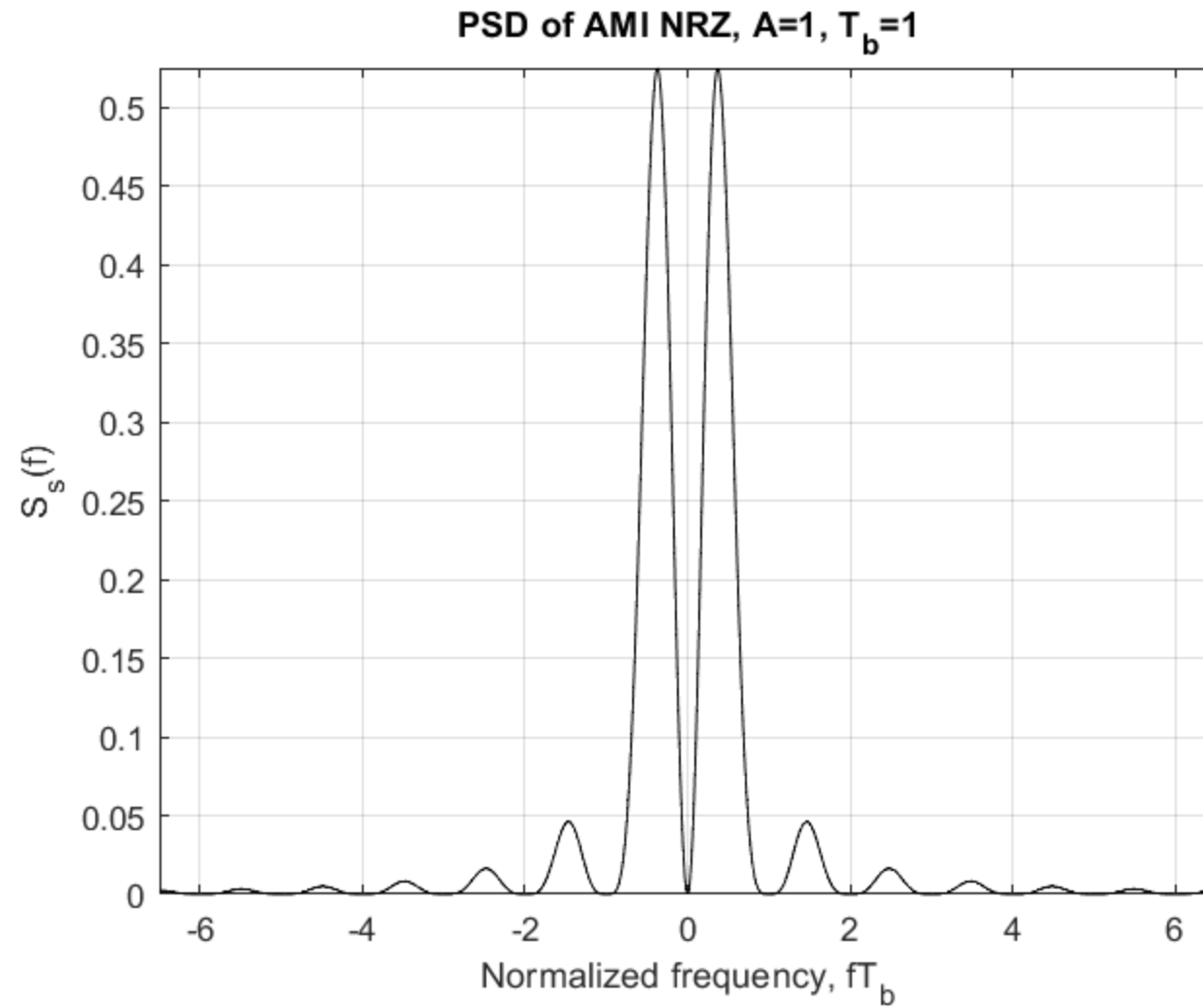
# Unipolar NRZ



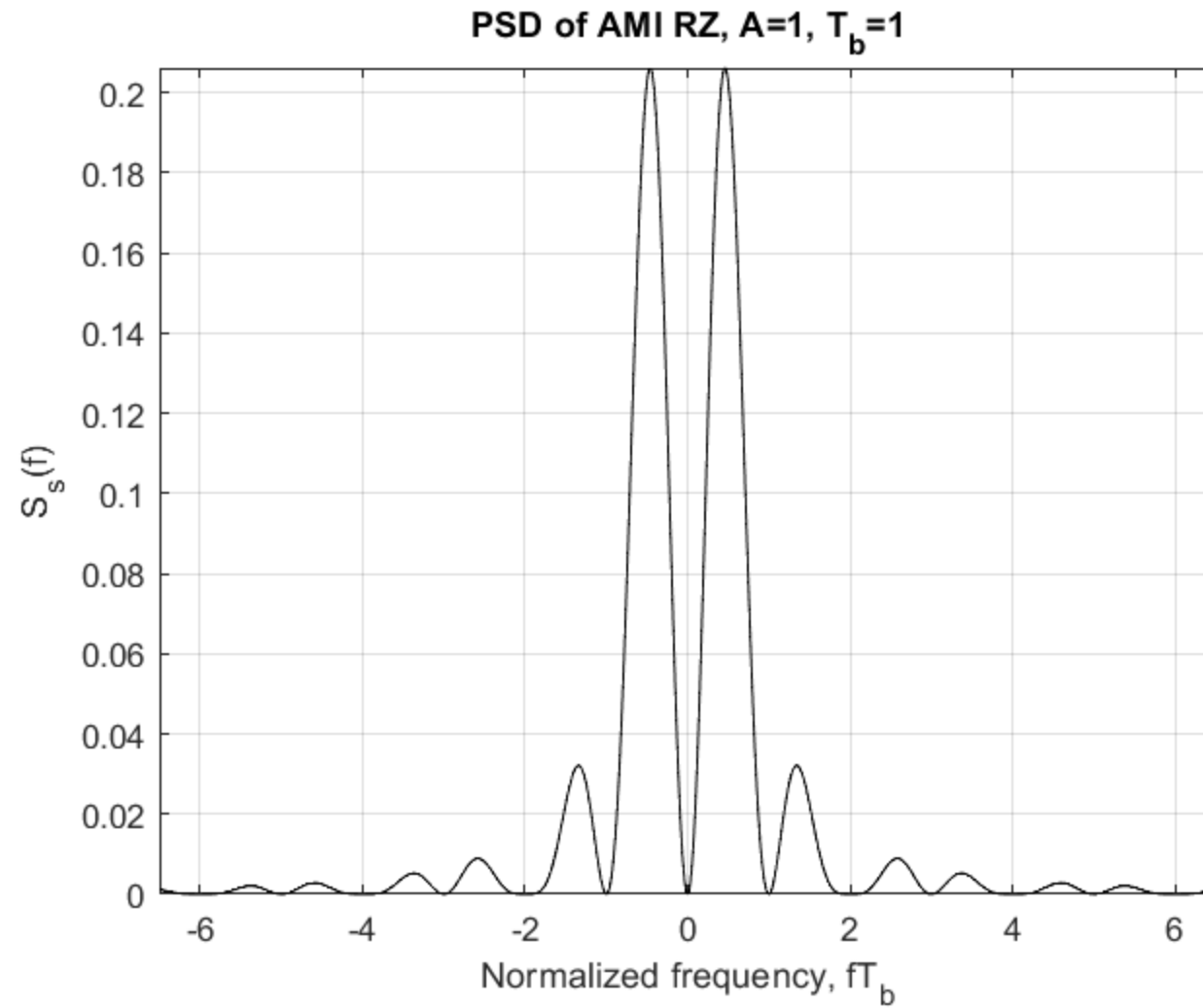
# Unipolar RZ



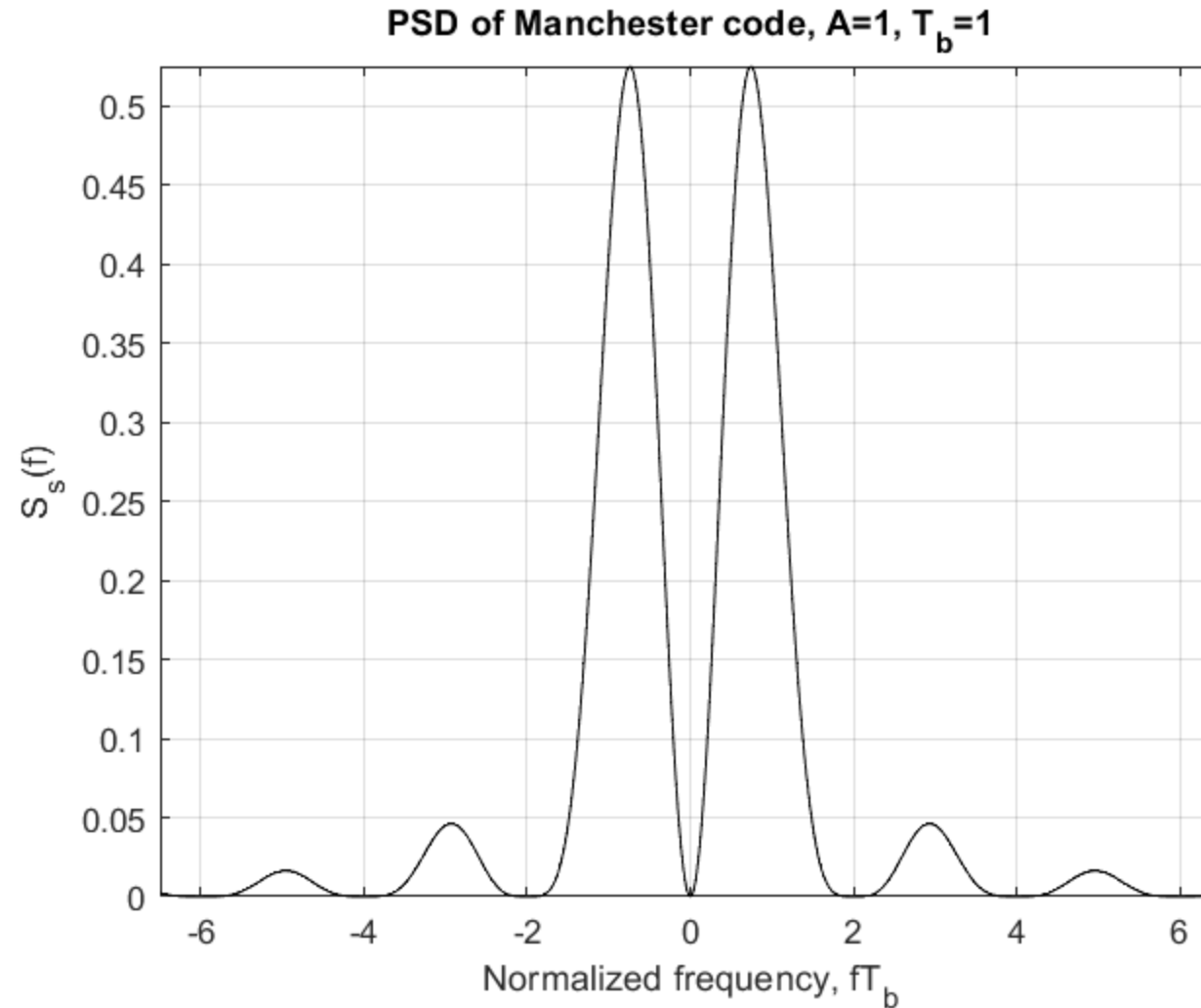
# AMI NRZ



# AMI RZ



# (Polar) Manchester



**NOTE:** The Manchester code is used in the first generation of Ethernet (IEEE 802.3 standard) and in second-generation RFID systems

# MATLAB Simulink model

