

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:

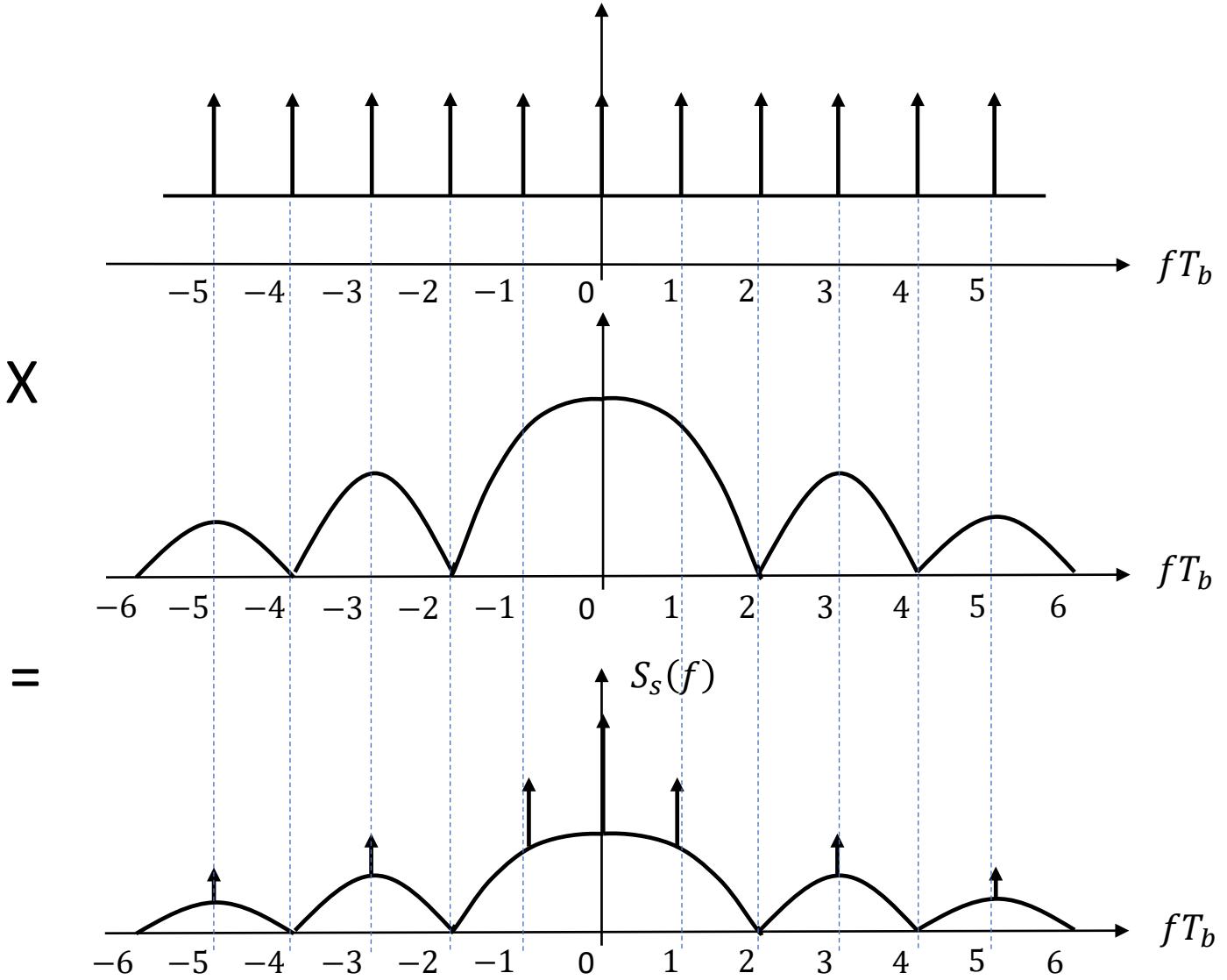
$$|G(f)| = \frac{T_b}{2} \left| \text{sinc}\left(f \frac{T_b}{2}\right) \right|$$

Graphical sketch

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

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

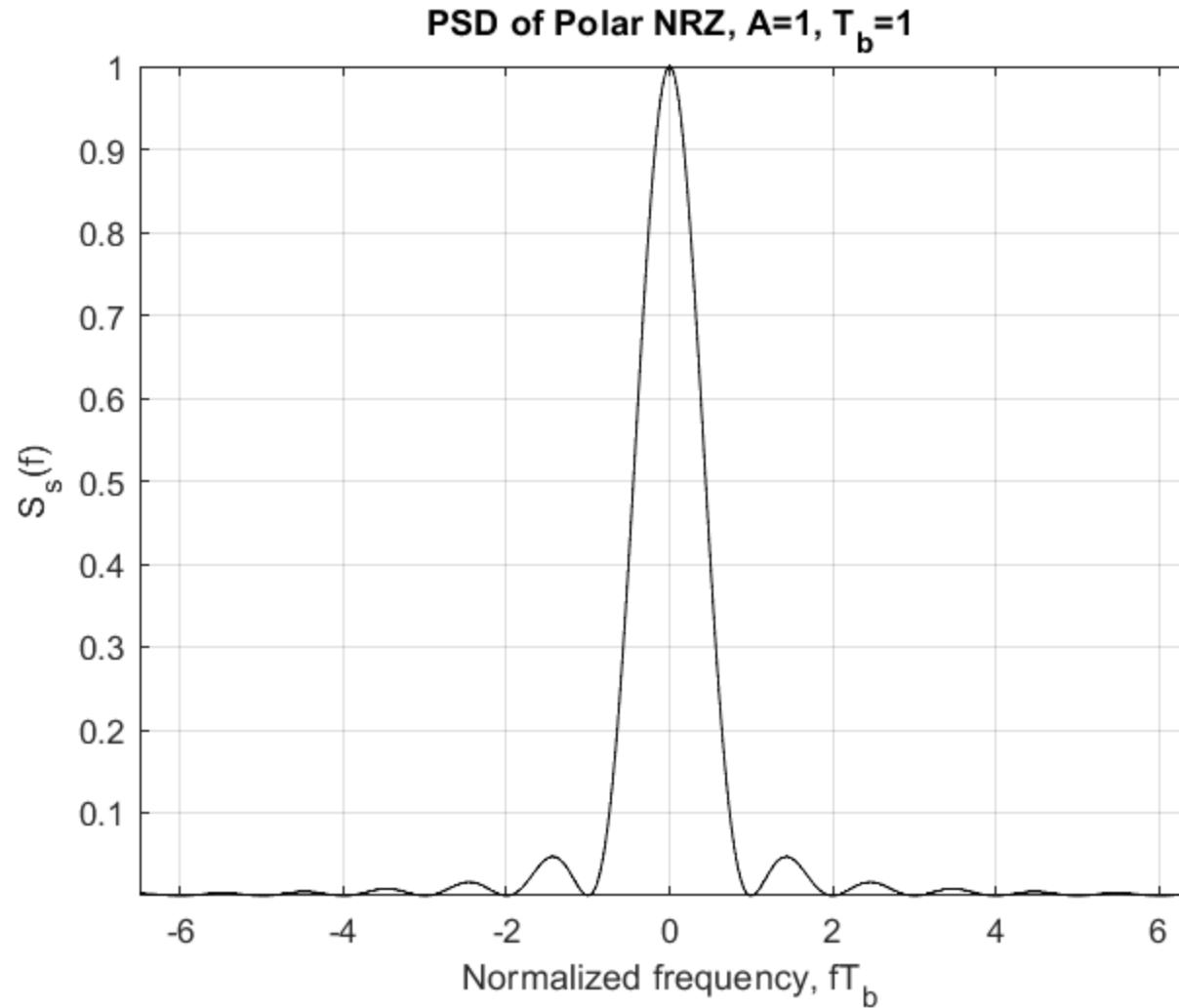
$$S_s(f) = \frac{a^2}{4T_b} |G(f)|^2 \left[1 + \frac{1}{T_b} \sum_{n=-\infty}^{\infty} \delta\left(f - \frac{n}{T_b}\right) \right]$$



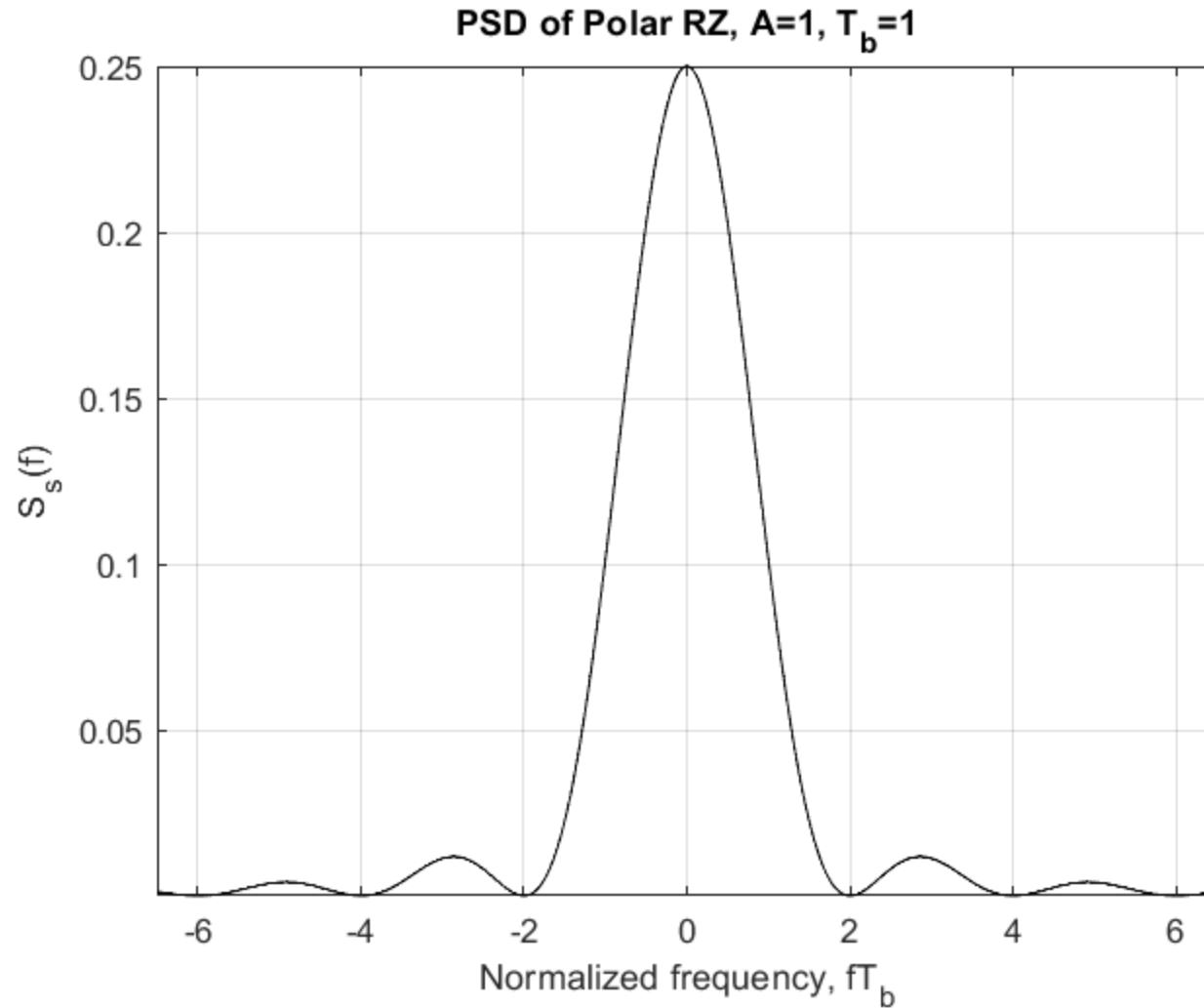
MATLAB plots*

* Script “plot_PSDs.m”

Polar NRZ

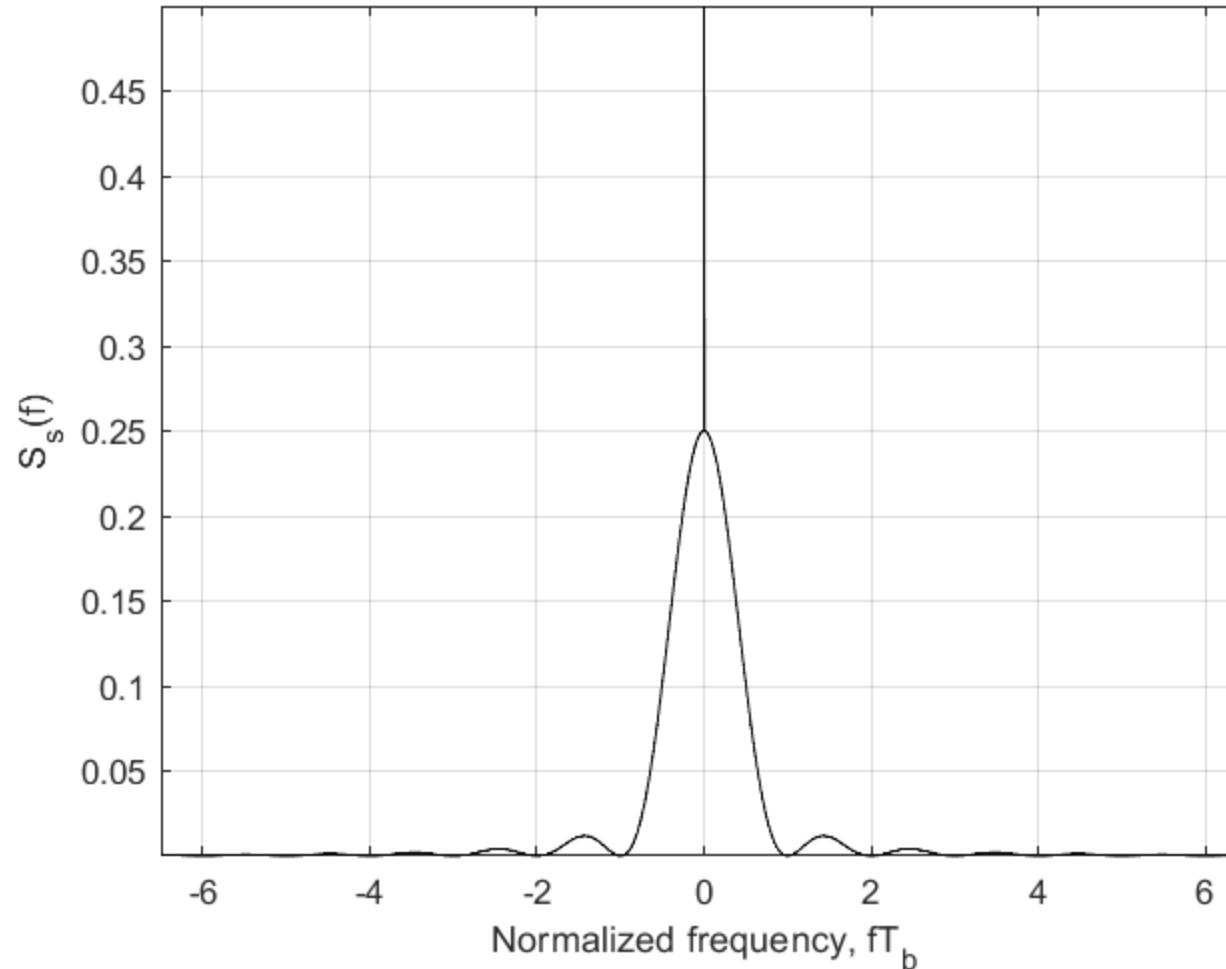


Polar RZ

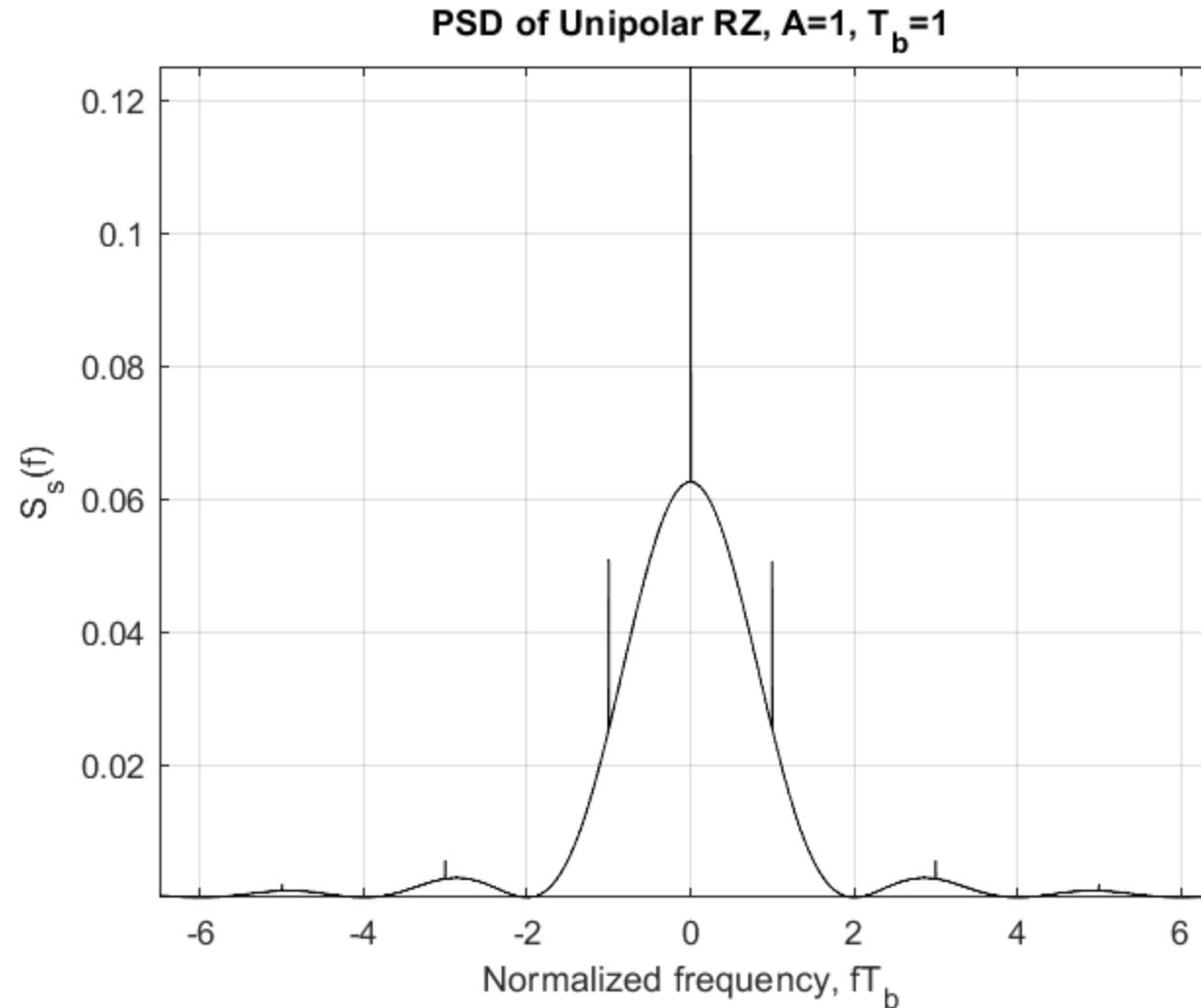


Unipolar NRZ

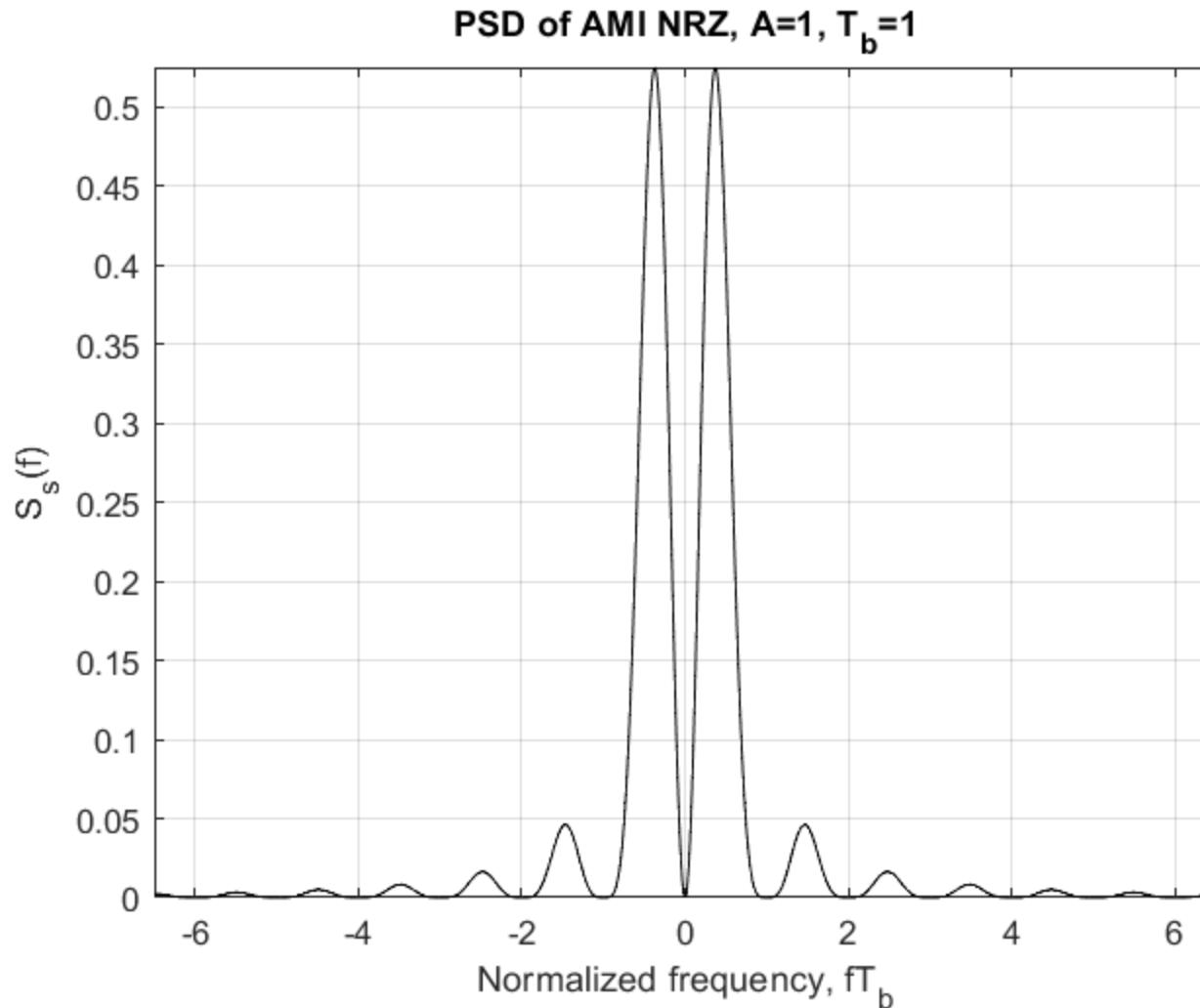
PSD of Unipolar NRZ, A=1, $T_b=1$



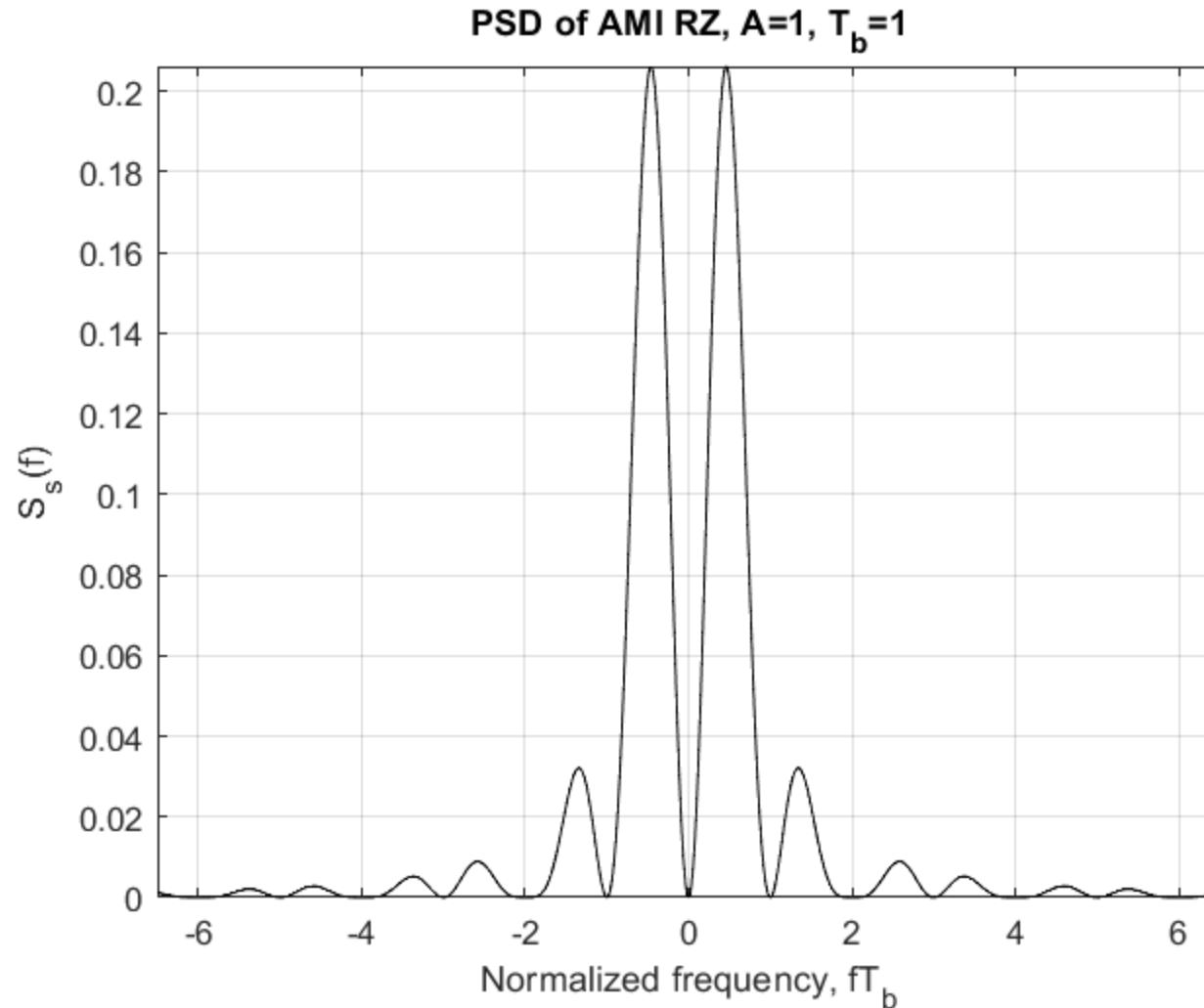
Unipolar RZ



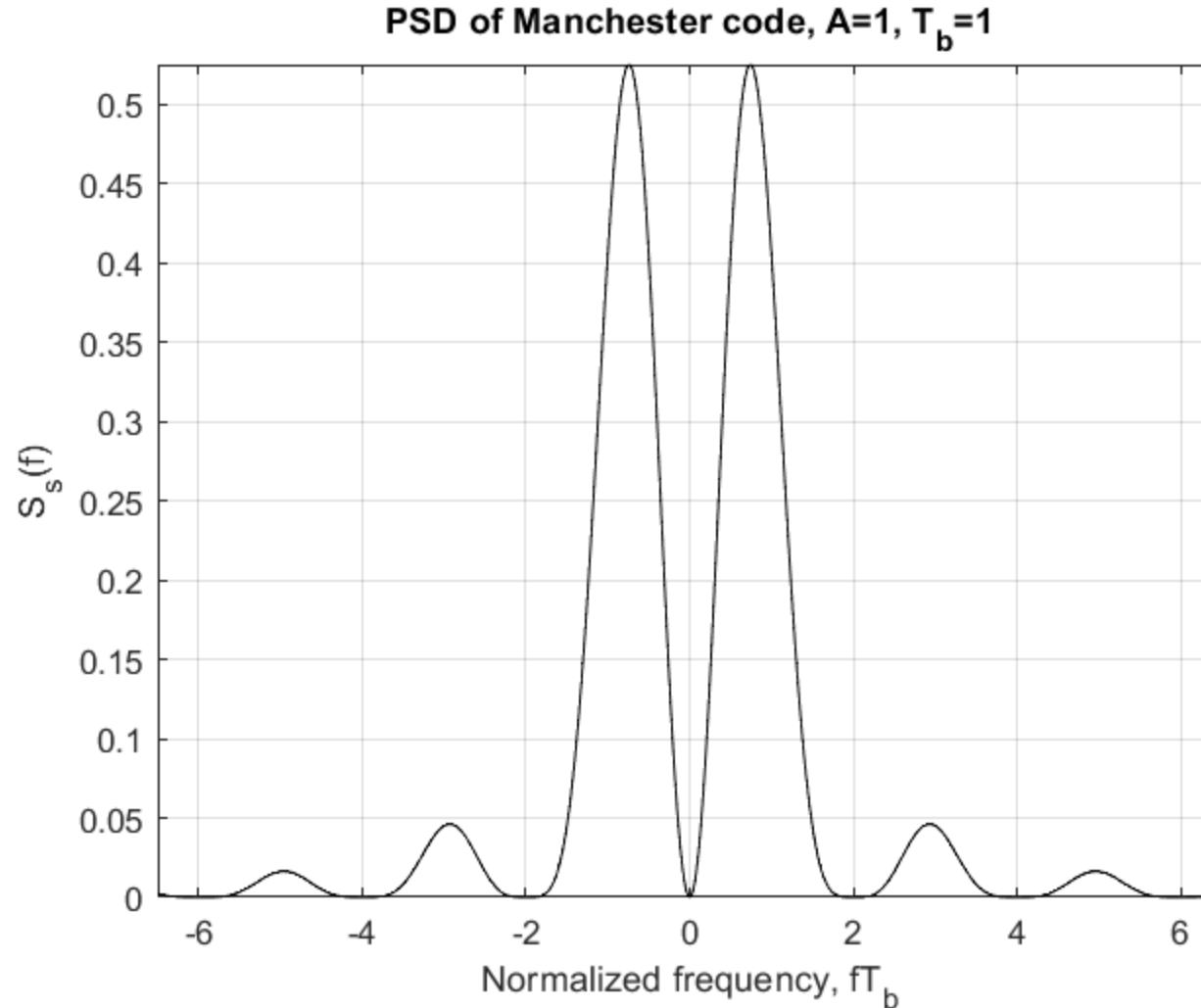
AMI NRZ



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

