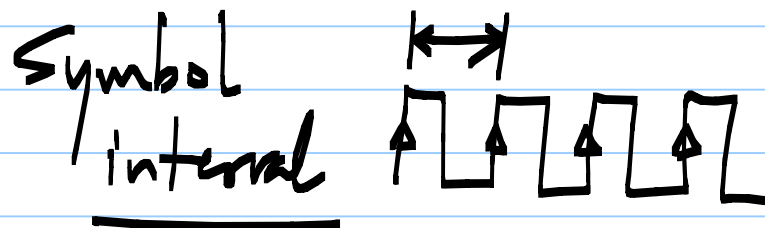
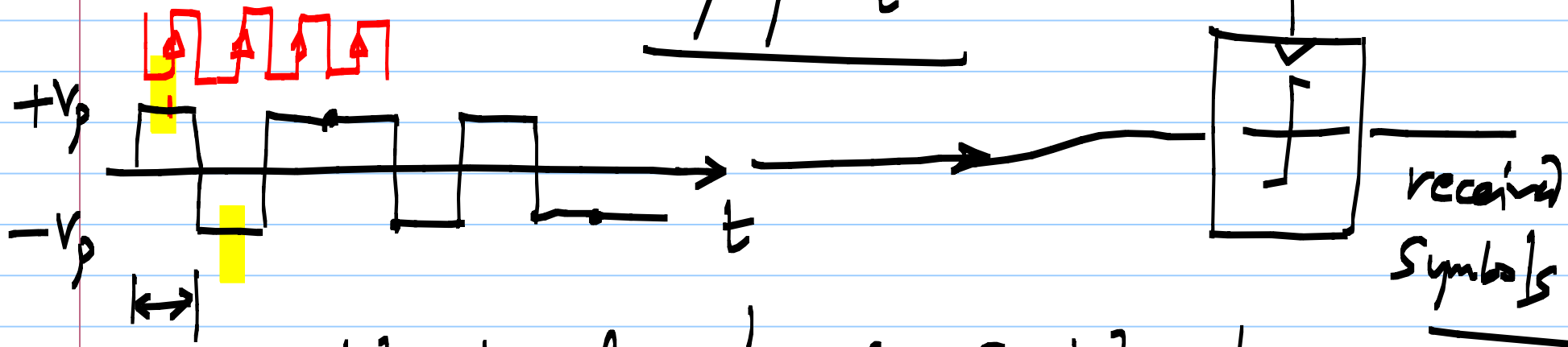


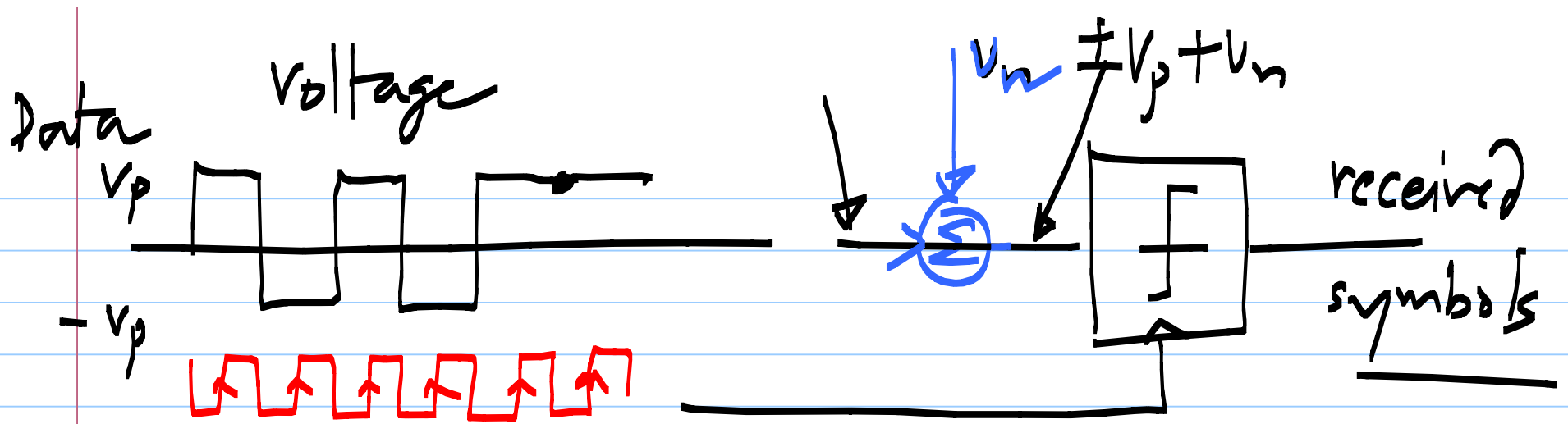
Digital data (binary)  
(discrete)



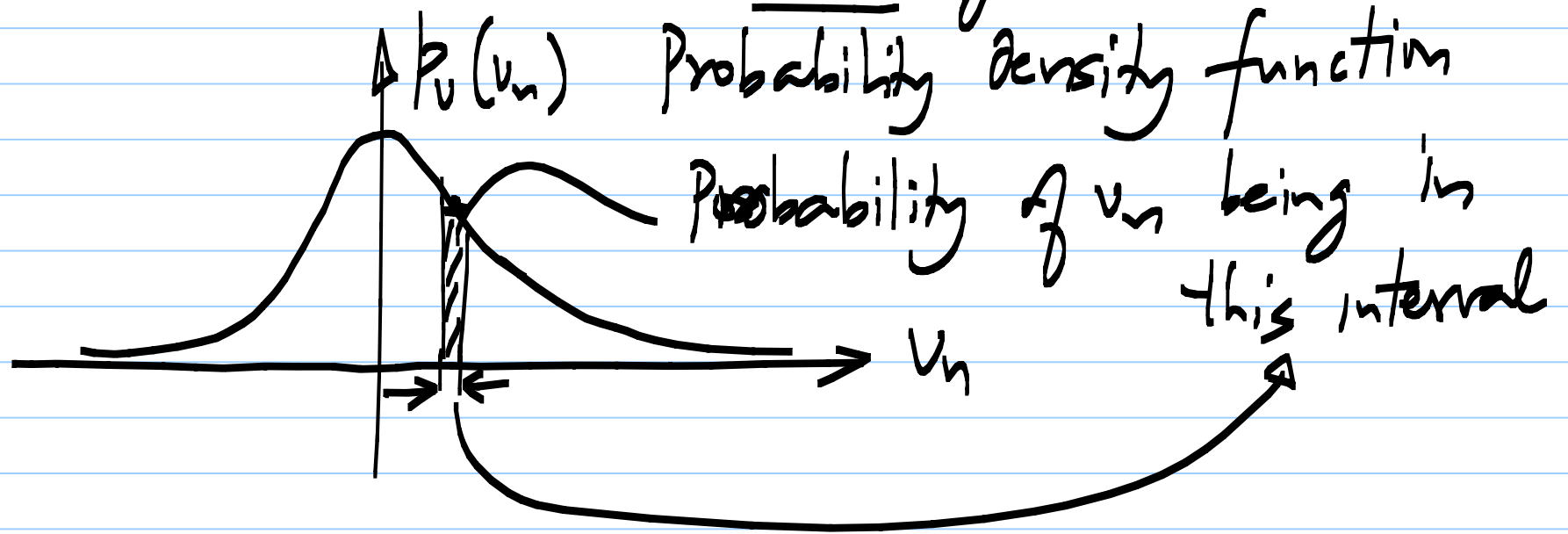
1 bit/symbol

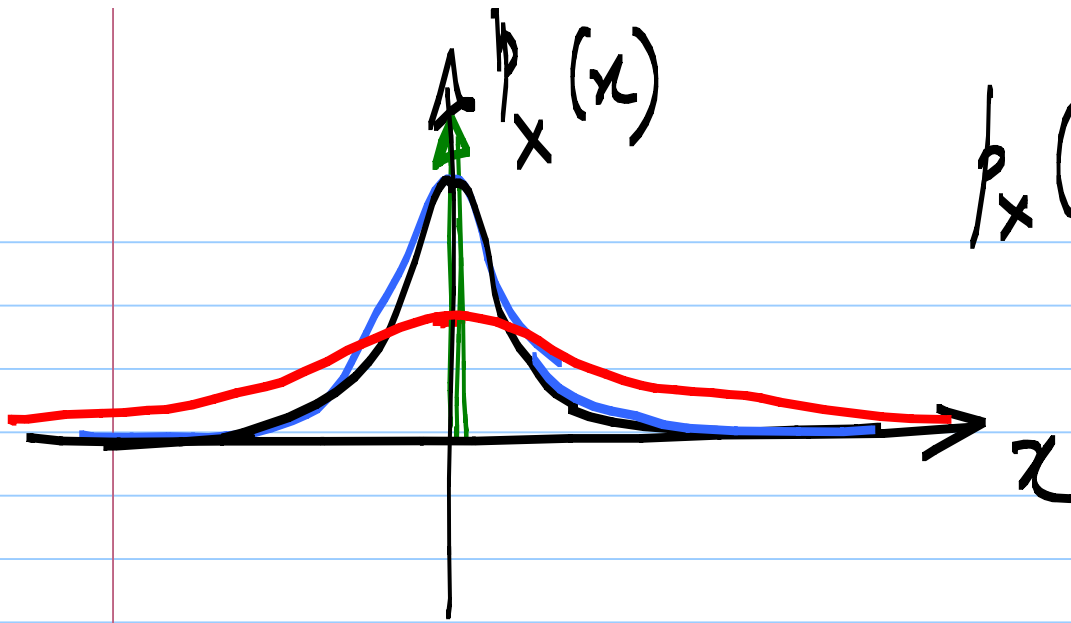


$T_s = \text{symbol interval}; \frac{1}{T_s} = f_s = \text{symbol rate}$



$V_n$ : random noise - white Gaussian noise



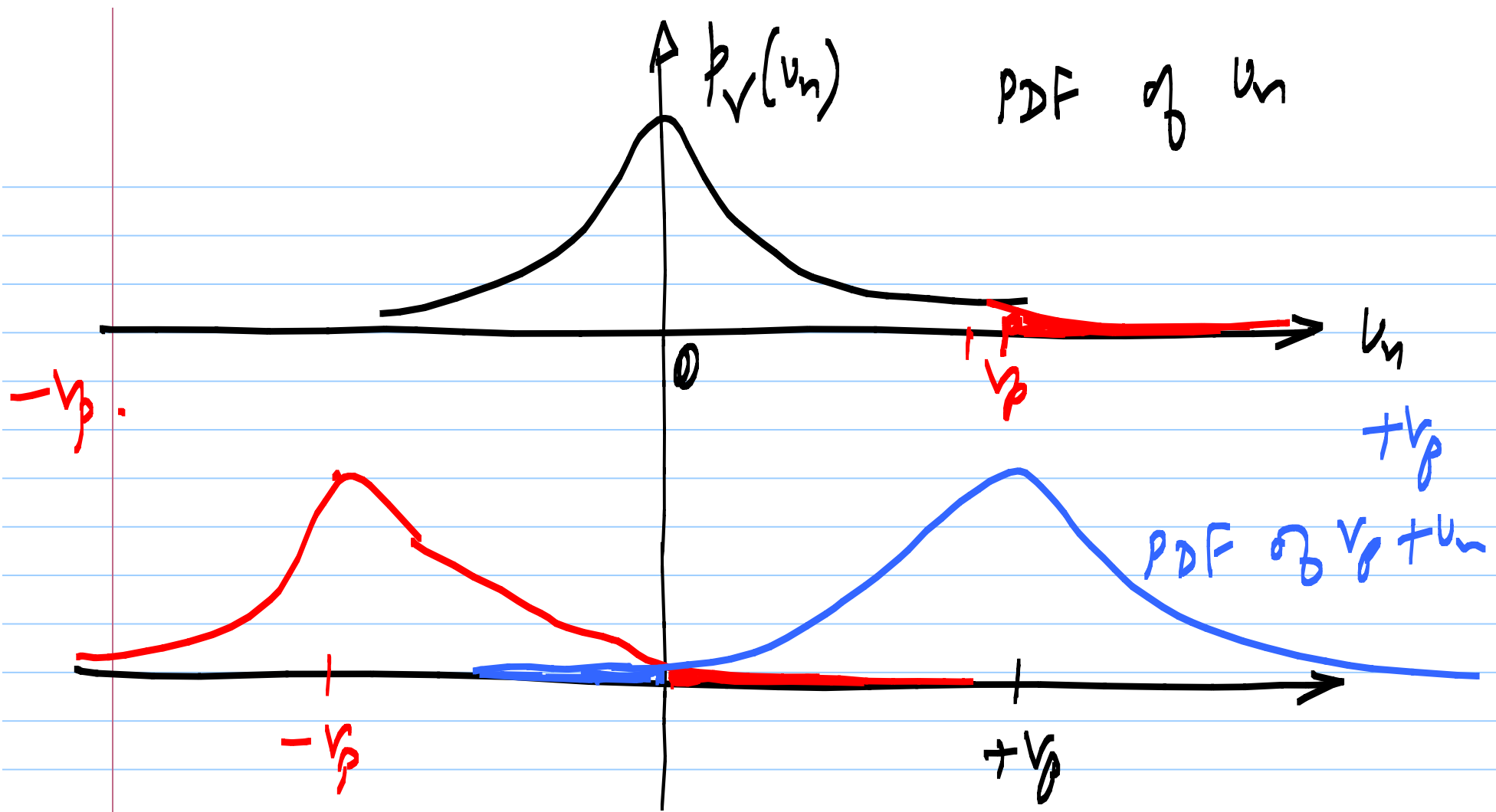


$$p_x(x) = \frac{1}{\sqrt{2\pi} \cdot \sigma} \exp\left(-\frac{x^2}{2\sigma^2}\right)$$

Standard deviation

Error:  $T_x: +1$  ;  $R_x = -1$

$T_x: -1$  ;  $R_x = +1$



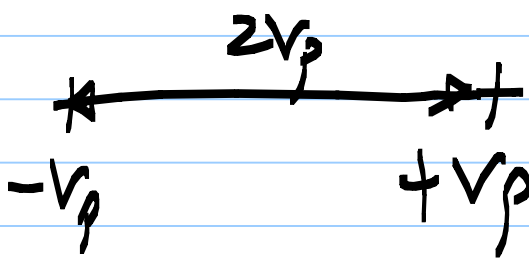
$$\begin{aligned}
 &P(1) \cdot P(\text{Error when 1 is sent}) \\
 &+ P(0) \cdot P(\text{Error when 0 is sent})
 \end{aligned}$$

$$p_v(v_n) = \frac{1}{\sqrt{2\pi} \sigma} \exp\left(-\frac{v_n^2}{2\sigma^2}\right).$$

Probability of Error:  $\int_{-\infty}^{\infty} p_v(v_n) \cdot dv_n$

$$= \frac{1}{\sqrt{2\pi} \sigma} \int_{-\infty}^{\infty} \exp\left(-\frac{v_n^2}{2\sigma^2}\right) dv_n$$

$= \underbrace{Q\left(\frac{v_p}{\sigma}\right)}$



The diagram shows a horizontal number line with arrows at both ends. A central point is marked with a vertical tick and labeled  $2v_p$  above it. Two other points are marked with vertical ticks and labeled  $-v_p$  on the left and  $+v_p$  on the right. This represents the interval  $[-v_p, v_p]$  with a total width of  $2v_p$ .

"Standard" Gaussian with  $\sigma = 1$

$$p_x(x) = \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{x^2}{2}\right)$$

$$Q(y) = \int_y^{\infty} p_x(x) \cdot dx$$

---

$$Q\left(\frac{v_p}{\sigma}\right)$$

$$\frac{v_p}{\sigma} = 6$$

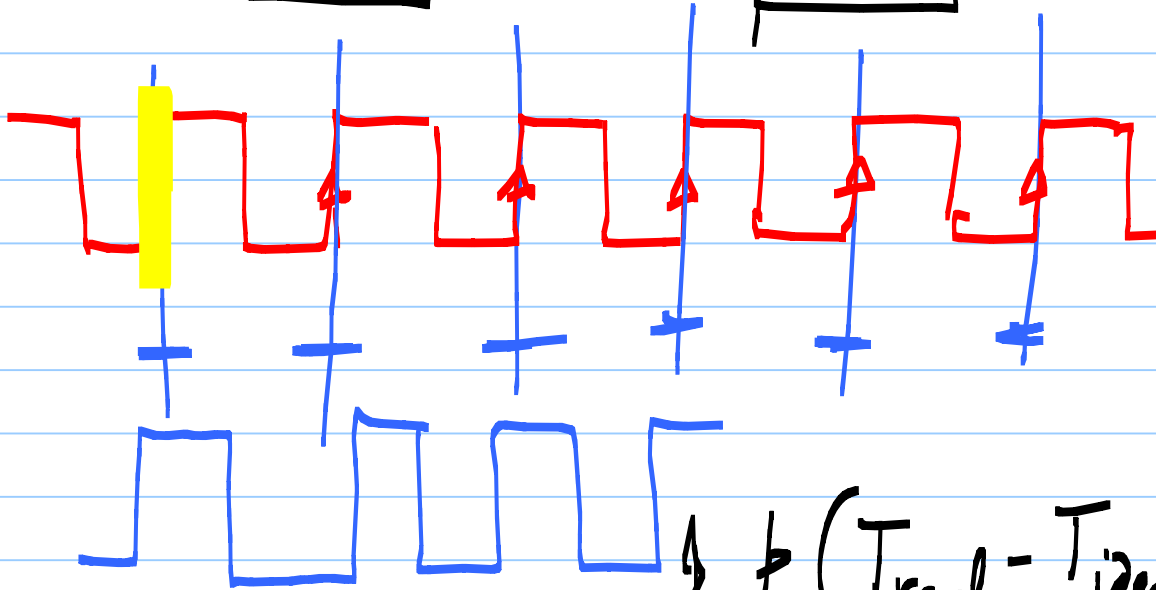
7  
8

$$Q\left(\frac{v_p}{\sigma}\right) \approx 10^{-9}$$

$$\approx 10^{-12}$$
$$\approx 10^{-5}$$

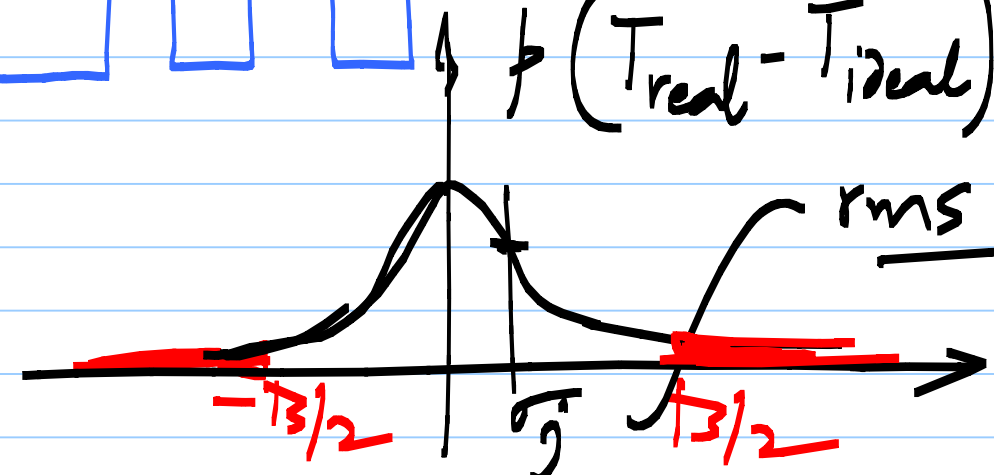


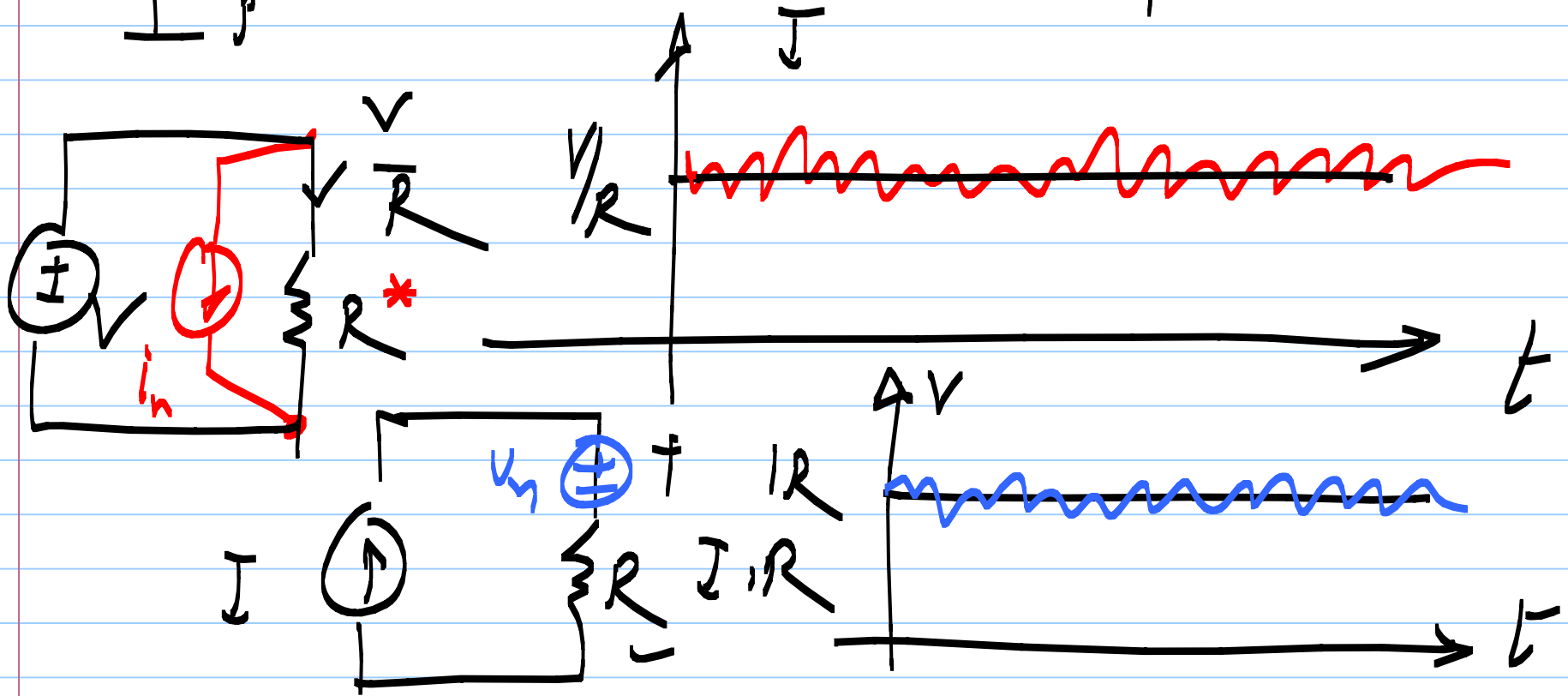
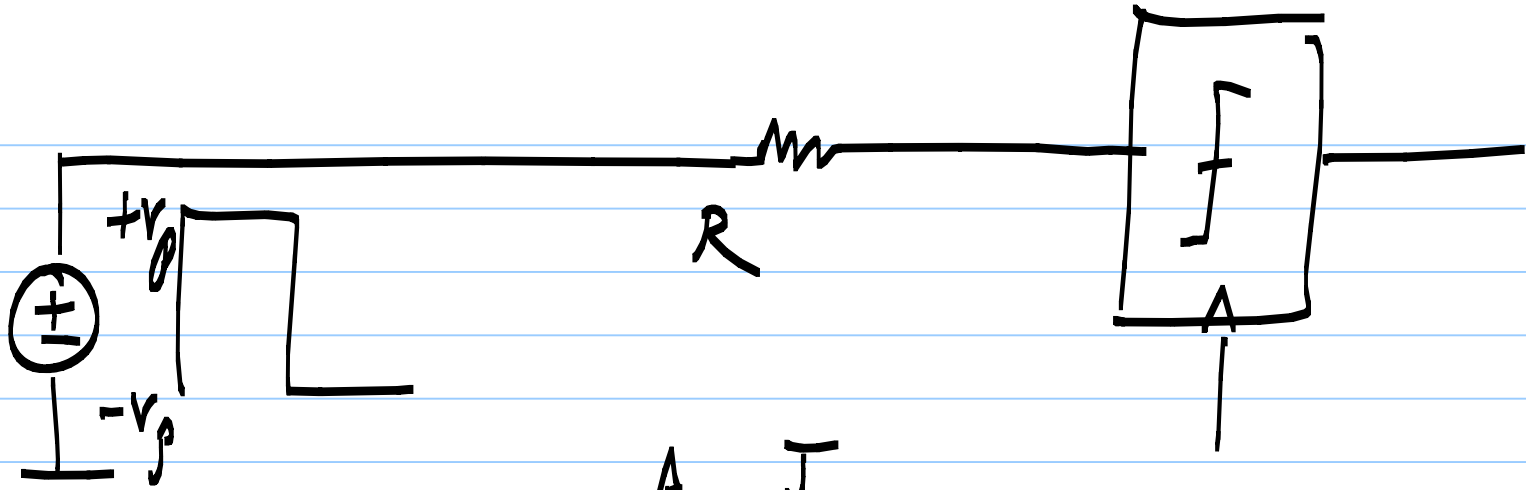
$$\sigma \left( \frac{T_s}{2\sigma_j} \right)$$



$$\sigma (T_{real} - T_{ideal})$$

rms jitter







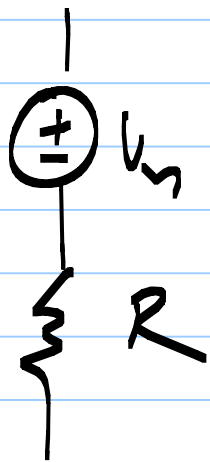
$A S_{V_n}$

$4kTR$

$2kTR$

$-\infty \leq \infty$

$f$



Spectral density  
is  $4kTR$

$f: 0 \leq \infty$