Problem Sheet: Information Sources Communication Systems

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1. The signal at the output of an analogue information source $x(t)$ having a uniform pdf between ± 2Volts, is passed through a half-wave and a full-wave rectifier circuits. Sketch and mathematically represent the pdfs of:

   (a) the original analogue information source, 5%

   (b) the output from the half-wave rectifier, 10%

   (c) the output from the full-wave rectifier. 10%

   (d) Determine

   - the mean value, and 15%
   - the rms value 15%

   of the signals in cases (a),(b) and (c) above.

   N.B.: Assume ideal diodes

2. Consider an analogue signal source $x(t)$ having a uniform amplitude probability density function

$$\text{pdf}_x(x) = \frac{1}{2a}\text{rect}\left\{\frac{x}{2a}\right\}$$

   (a) Estimate the average power P_x of the signal $x(t)$. 10%

   (b) Find the differential entropy H_x of the signal source $x(t)$ 10%

   (c) Find $H_y - H_x$ 10%
   where H_y denotes the differential entropy of an analogue signal source $y(t)$ having a Gaussian amplitude probability density function with mean μ_y and $\sigma_y = \sqrt{P_x}$

   (d) What is the entropy power of the signal $x(t)$. 10%

3. A signal $g(t)$ having the pdf shown in Fig.1 is bandlimited to 4 kHz. The signal is sampled at the Nyquist rate and is fed through a 2-level quantizer. The transfer function of the quantizer is shown in Fig.2.

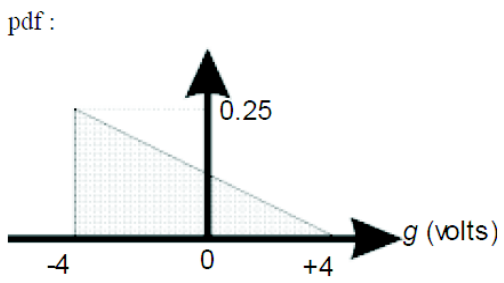


Fig. 1

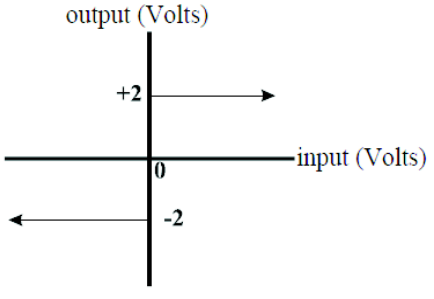


Fig. 2

Consider the output of the quantizer as the output of a discrete information source $(X, \underline{p})$. Calculate:

(a) the symbol rate r_X of the source $(X, \underline{p})$. 10%

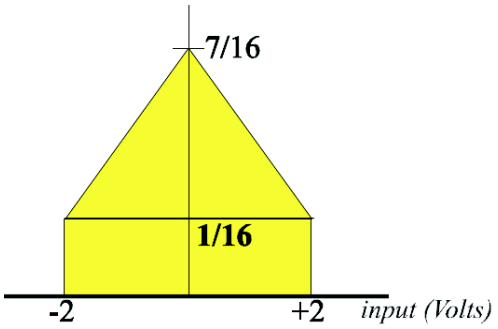
(b) the amplitude pdf of the signal at the quantizer's output. Sketch this pdf. 10%

(c) the rms value of the signal at the output of the quantizer. 10%

(d) the entropy H_X 10%

(e) the entropy of the source $(X \times X, \mathbb{J})$ (10%)

4. A signal $g(t)$ having the probability density function (pdf) shown below is sampled and fed through an 4-level quantizer. Consider the output of the quantizer as the output of a discrete



information source $(X, \underline{p})$.

(a) Calculate and sketch the pdf of the signal at the output of the quantizer. 10%

(b) Calculate the rms value of the signal at the output of the quantizer. 10%

(c) What is the ensemble of the source $(X \times X, \mathbb{J})$? 10%

(d) Calculate the entropy $H_{X \times X}$ 10%

END