Försättsblad Prov Original

Kurskod	Provkod	Tentamensdatum
ET096G	T101	2019-01-09

Kursnamn	Elektroteknik GR (B), Mätteknik
Provnamn	Skriftlig tentamen
Ort	Sundsvall
Termin	
Ämne	

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Utskriven 2019-01-14 kl. 13:40:10

Exam time: 5 hours
Aids: Electronic calculator, if relevant, a dictionary or electronic dictionary between English and the students home language.
Teacher: Börje Norlin

Number of tasks: 5

Number of pages: 6

Maximum points: 30 (15 points required to pass)

Instructions for submitted solutions:

• Rationale and justifications may not be so scarce that they become difficult to follow.

• The reasoning behind your solutions should be explained.

• Calculations must be sufficiently complete to show how the final result was obtained.

1. Explain by using the properties of the *Expected value* and *Variance* why the Signal-to-Noise-Ratio is improved for a signal *Y* that is calculated as mean value taken from samples of signal *X* according to $Y = \frac{X_1 + X_2 + K + X_N}{N}$ where all samples contain equal amount of white noise. The answer must be a developed mathematical expression for how the SNR_Y of *Y* relates to the SNR_X of *X*.

6p

2. During an experiment, the temperature was measured using a resistive temperature element. The measured "temperature" was noted as 320 Ω. However, there were three resistive temperature probes available, one labelled Pt-100, the 2:nd labelled Ni-100 and the third labelled Ni-1000. In the lab notes the information about which probe was used for the measurement is missing. Calculate the three possible temperature values that might have been measured at this occasion. Comment on the result.

6p

Help: $R_T = R_0(1 + \gamma)$

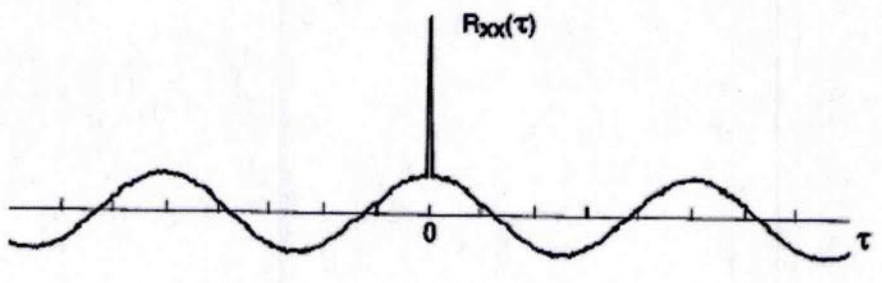
Material	*Temperature coefficient γ (°C^{-1})*
Platinum	$3.85 \cdot 10^{-3}$
Nickel	$6.75 \cdot 10^{-3}$
Copper	$4.33 \cdot 10^{-3}$

3. A resistive sensor connected in a quarter bridge is assembled in one end of a factory. On another end of the factory, about 50 meters from the sensor, a process controller equipment has an analog input for receiving the mentioned sensor signal. Draw a picture, give suggestions and motivate shortly solutions for transferring and interfacing the analog sensor output signal by a cable from the sensor to the controller. You are supposed to take greatest possible care in reducing noise interference stemming from 50Hz power lines and from adjacent electronic equipment.

6p

4. The figure below shows the autocorrelation of a signal. Based on this autocorrelation, draw a picture of the signal in the time domain with as much detail as you can (you can select your own scales for the axes). Explain which part of the autocorrelation each piece of information comes from.

6p



Figure

5. A company located in China is producing liquid containers equipped with a capacitive water level measurement functionality. All produced units are delivered with an individual calibration curve described by a set of coefficients. This calibration is necessary due to imperfections and variations in manufacturing. A second order polynomial is used such that capacitance $C=K_0 + K_1 L + K_2 L^2$ where L is the level in meter, $(K_0\ K_1\ K_2)$ are the coefficients. This polynomial is used to fit data acquired for series of observations on capacitance and level.

   a) Define the matrixes for an overdetermined equation system LK=C and define those matrixes for N number of observations.

   3p

   b) Sketch and describe the major system components necessary for an automated calibration of produced sensors. Describe shortly the functionality of the system.

   3p

Good Luck!
BÖRJE

Properties for the *Expected value*

$$E(X) \equiv \int_{-\infty}^{\infty} x \cdot f(x) \cdot dx \text{ , } f(x) \textit{ is the pdf of } X$$

$E(a \cdot X) = a \cdot E(X)$, a is a constant

$E(X + Y) = E(X) + E(Y)$

$E(X \cdot Y) = E(X) \cdot E(Y)$, only if X and Y are statistica lly independent

Properties for the *Variance*

$V\{X + Y\} = V\{X\} + V\{Y\}$, only if X and Y are statistica lly independent

$V\{aX\} = a^2 \cdot V\{X\}$, a is a constant

$V\{X\} = \sigma^2$, σ is the standard deviation

$V\{X\} \equiv E\{(X - \mu)^2\}$

$V\{X\} = E\{X^2\} - \mu^2$

Autocorrelation

For an analog energy signal, it is defined as: $$R_{xx}(\tau) \equiv \int_{-\infty}^{\infty} x(t) \cdot x(t+\tau)\, dt$$

For an analog power signal, it is defined as: $$R_{xx}(\tau) \equiv \frac{1}{T}\int_{0}^{T} x(t) \cdot x(t+\tau)\, dt$$

For a time discrete energy signal, it is defined as: $$R_{xx}[k] \equiv \sum_{n=-\infty}^{\infty} x[n] \cdot x[n+k]$$

For a time discrete power signal, it is defined as: $$R_{xx}[k] \equiv \frac{1}{N}\sum_{n=0}^{N-1} x[n] \cdot x[n+k]$$

For an analog power signal Described as a stochastic process: $$R_{xx}(\tau) \equiv E\{x(t) \cdot x(t+\tau)\}$$

For a time discrete power signal Described as a stochastic process: $$R_{xx}[k] \equiv E\{x[n] \cdot x[n+k]\}$$

The autocorrelation function for the sum of several statistically independent signals equals the sum of the autocorrelation for each of the signals.

$$R_{(x+y)(x+y)}(\tau) = R_{xx}(\tau) + R_{yy}(\tau)$$