LET271 Elmät Tentamen 2014-03-13

1a) Om givare o mätobjekt har olika temperaturutvidgningskoeff så kan tempvariationer se ut som "verklig" töjning.

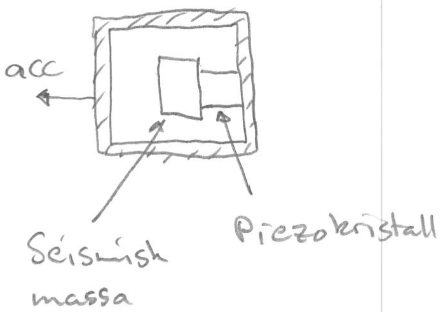
Reducering:
- 2 aktiva motverkande givare i halvbrygga.
- Givare med samma temp.utv.koeff som mätobjekt

1b)

+ Billigare
+ Större givarkonstant

− Olinjärare
− Större tolerans

1c)



acc → kraft på kristall från seismisk massa → → deformation av kristall → spänning över kristall

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1d)

+ Brantare övergång från passband till spärrband
+ Rippel i passband ⇒ Större förvrängning av signal

1e) Viktigast: Använd trinnade kablar.
Öka avstånd från störkälla till störoffer

2a) Samplingsteoremet: Välj $f_s > 2 \cdot f_{max}$ där f_{max} maxfrekvens i signal.

$$\underline{\underline{f_s}} > 2 \cdot 700\,\text{kHz} = \underline{\underline{1{,}4\,\text{MHz}}}$$

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b)

$u_{min} = 4{,}5 - 4{,}5 = 0\,V$

$u_{max} = 4{,}4 + 4{,}5 = 9\,V$

$$\Rightarrow \underline{\underline{U_{ref} \geq}}\ u_{max} - u_{min} = \underline{\underline{9V}}$$

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c) Från b) antag $U_{ref} = 10V$.

Ur uppgift: $\Delta U = 0{,}65\,mV$

$$\Delta U = \frac{U_{ref}}{2^n} \Rightarrow n = \frac{\ln \frac{U_{ref}}{\Delta U}}{\ln 2} = \frac{\ln \frac{10}{0{,}65 \cdot 10^{-3}}}{\ln 2} = 13{,}9 \quad \underline{\underline{\text{Välj } n = 14}}$$

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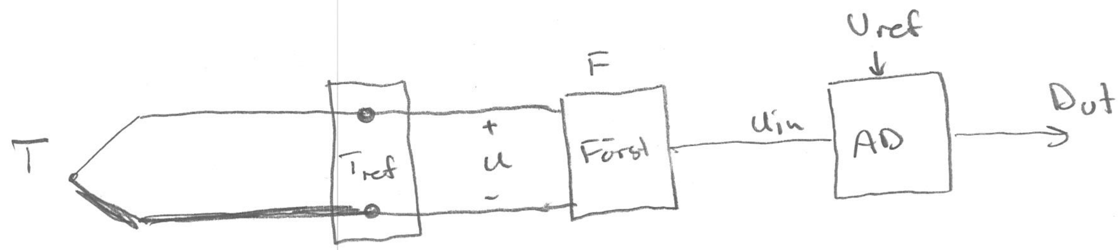
3)



$U_{ref} = 5\,V \quad n = 8 \quad F = 100 \quad D_{ut} = 23 \quad T_{ref} = 25\,°C$

$\Delta U = \frac{U_{ref}}{2^n} = \frac{5}{2^8} = 19{,}531\,mV$

$u_{in} = D_{ut} \cdot \Delta U \pm \frac{\Delta U}{2} = 449{,}2 \pm 9{,}8\ mV \qquad 439{,}4\,mV \leq u_{in} \leq 459{,}0\,mV$

$\underline{u} = \frac{u_{in}}{F} \Rightarrow \underline{4{,}394\,mV \leq u \leq 4{,}590\,mV}$

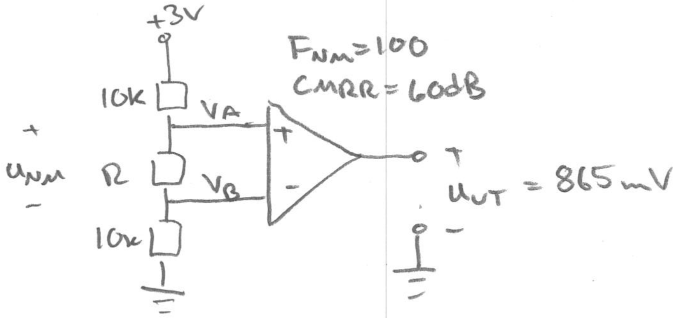
Ur tabell $E_{AB}(T_{ref} \to 0°) = E_{AB}(25°C \to 0°) = 0{,}992\ mV$

Ur FS $\underline{E_{AB}(T \to 0°)} = u + E_{AB}(T_{ref} \to 0°) = \underline{u + 0{,}992\,mV}$

$\therefore \quad 5{,}386\,mV \leq E_{AB}(T \to 0°) \leq 5{,}582\,mV$

Ur tabell $\underline{\underline{123°C \leq T \leq 127°C}}$

4)



$F_{NM} = 100$
CMRR = 60dB

$$u_{cm} = \frac{V_A + V_B}{2} = 1{,}5\,V$$

$$CMRR_{dB} = 20\log\frac{F_{NM}}{F_{cm}} \Rightarrow F_{cm} = \frac{F_{NM}}{10^{\frac{CMRR}{20}}} = \frac{100}{10^{\frac{60}{20}}} = 0{,}1$$

$$u_{UTcm} = F_{cm} \cdot u_{cm} = 0{,}1 \cdot 1{,}5 = 0{,}15\,V$$

$$u_{UTNM} = u_{UT} - u_{UTcm} = 0{,}865 - 0{,}15 = 0{,}715\,V$$

$$u_{NM} = V_A - V_B = \frac{u_{UTNM}}{F_{NM}} = \frac{0{,}715}{100} = 7{,}15\,mV$$

$$u_{NM} = \frac{R}{R + 20000} \cdot 3V \Rightarrow R = \frac{20000 \cdot u_{NM}}{3{,}0 - u_{NM}} = \frac{20000 \cdot 7{,}15 \cdot 10^{-3}}{3{,}0 - 7{,}15 \cdot 10^{-3}} = 47{,}78\,\Omega$$

Pt-100 $\quad R = 100 + 0{,}385 \cdot T \Rightarrow \underline{\underline{T}} = \frac{R - 100}{0{,}385} = \frac{47{,}78 - 100}{0{,}385} = \underline{\underline{-136\,°C}}$

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5)

$$x(t) = 6 + 3\cos(500\pi t - 70^\circ) + \sin(1000\pi t + 50^\circ) - 4\cos(3000\pi t)$$

$f_0 = 0$ $\quad A_0 = 6$

$f_1 = 250\,Hz$ $\quad A_1 = 3$

$f_2 = 500\,Hz$ $\quad A_3 = 1$

$f_4 = 1500\,Hz$ $\quad A_4 = 4$

$f_s = 5\,kS/s$

$N = 40$

$$\Delta f = \frac{f_s}{N} = \frac{5000}{40} = 125\,Hz$$

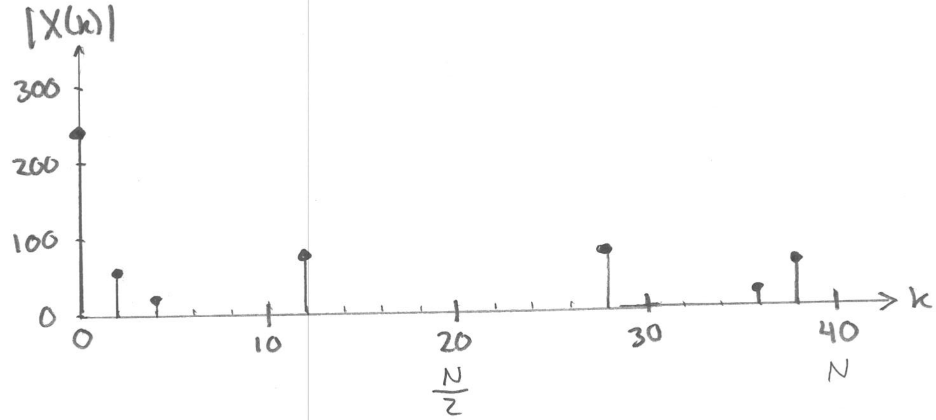
$$f = k \cdot \Delta f \Rightarrow k = \frac{f}{\Delta f} = \frac{f}{125\,Hz}$$

$$|X(0)| = N A_0 = 40 \cdot 6 = 240$$

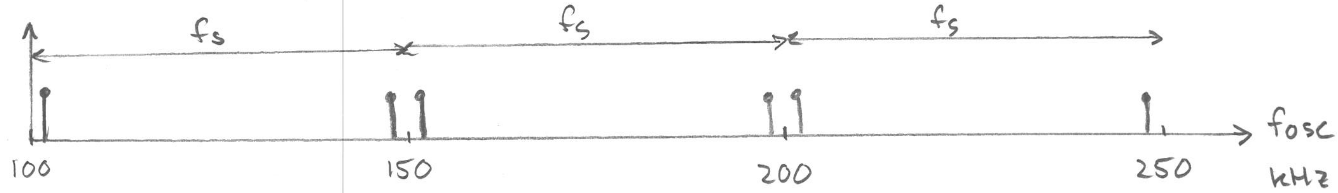
$k \neq 0$ $\quad |X(k)| = N \dfrac{A_k}{2} = 20 \cdot A_k$

f (Hz)	A	k	|X(k)|
0	6	0	240
250	3	2	60
500	1	4	20
1500	4	12	80

Symmetri $|X(N-k)| = |X(k)|$



6)



Vikning har skett. $f = m \cdot f_s \pm f_1$ viks ner till f_1. m heltal

Ur spektrum ovan fås $\underline{\underline{f_s = 50\,kHz}}$

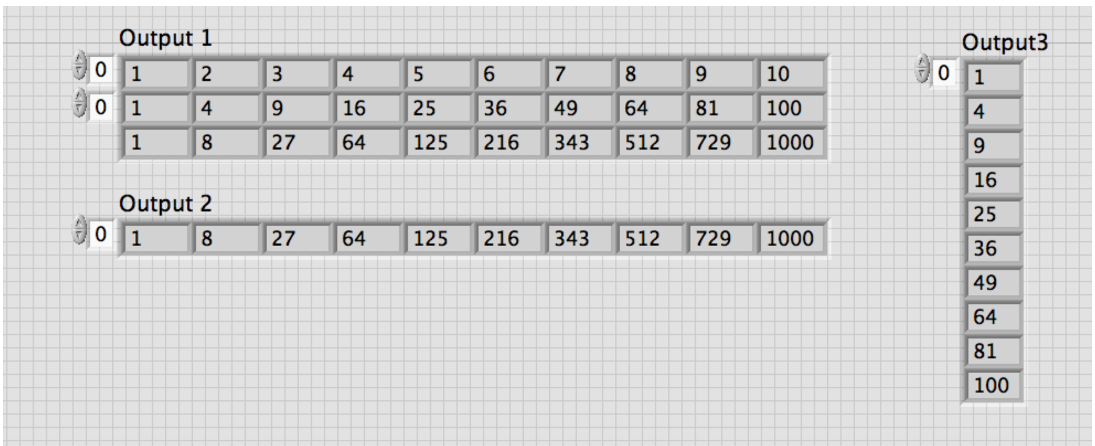
- Exercise 7:

  a) "CONF:FRES" configures the multimeter for 4-wire resistance measurements.
  b) The command "READ" triggers a measurement from the multimeter.
  c) Wiring an error cluster through the GPIB blocks ensures that they are executed in the right order; it also allows one to track the error messages.

- Exercise 8:

  a) A *formula node*, which compute the value of the resistance as a function of the temperature; and two *while loops*: the outermost makes sure that the program runs until the *stop* button is pressed; the innermost one makes sure that the resistance is recomputed every time the *ok button* is pressed. There are also the following blocks: a *greater than zero* block, which verifies with the input is larger than 0; A *select* block, which assigns two different values to the constant c according to whether the temperature is above or below 0.
  b) If $T \geq 0$
  $$R = 100 \times \left[1 + 0.0039083 \times T - 5.775 \times 10^{-7} \times T^2\right].$$
  If $T < 0$
  $$R = 100 \times \left[1 + 0.0039083 \times T - 5.775 \times 10^{-7} \times T^2 - 4.183 \times 10^{-12} \times (T - 100) \times T^3\right].$$
  c) $0\,°\mathrm{C} \rightarrow 100\,\Omega$; $100\,°\mathrm{C} \rightarrow 138.505\,\Omega$
  d) $0\,°\mathrm{C} \rightarrow 100\,\Omega$; $100\,°\mathrm{C} \rightarrow 100\,\Omega$
  e) The output of the program is the same as in task d). However, the program keeps on recomputing the value of the resistance, which is not very efficient computationally.

- Exercise 9:



- Exercise 10:

  a) $R = 109.0483\,\Omega$
  b) $s(R) = 4.07 \times 10^{-2}\,\Omega$; hence, $u_A(R) = s(R)/\sqrt{7} = 1.54 \times 10^{-2}\,\Omega$
  c) The extreme points of the 95% confidence interval are $109.0483 \pm 2.57 \times 1.54 \times 10^{-2} = 109.0483 \pm 0.0395$. So the 95% confidence interval is $[109.0088, 109.0879]$.

d)

$$u_B(R) = \frac{1}{\sqrt{3}} \left(\frac{0.03}{100} 109.0483 + \frac{0.03}{100} 100 \right) = 3.62 \times 10^{-2}\,\Omega.$$

Hence,

$$u(R) = \sqrt{u_A^2(R) + u_B^2(R)} = 3.93 \times 10^{-2}\,\Omega.$$

e)

$$T = \frac{1}{\gamma} \left(\frac{R}{R_0} - 1 \right) = 23.50\,^\circ\mathrm{C}.$$

f) $u(\gamma) = 1.732 \times 10^{-5}\,^\circ\mathrm{C}^{-1}$; $u(R_0) = 3.464 \times 10^{-2}\,\Omega$. Now we compute the sensitivity coefficients:

$$c_R = \frac{\partial T}{\partial R} = \frac{1}{\gamma R_0} = 2.5974\,^\circ\mathrm{C}\,\Omega^{-1}.$$

$$c_\gamma = \frac{\partial T}{\partial \gamma} = -\frac{1}{\gamma^2} \left(\frac{R}{R_0} - 1 \right) = -6.1045 \times 10^3\,^\circ\mathrm{C}^2.$$

$$c_{R_0} = \frac{\partial T}{\partial R_0} = -\frac{R}{\gamma R_0^2} = -2.8324\,^\circ\mathrm{C}\,\Omega^{-1}.$$

Finally,

$$u(T) = \sqrt{(c_R u(R))^2 + (c_\gamma u(\gamma))^2 + (c_{R_0} u(R_0))^2} = 0.18\,^\circ\mathrm{C}.$$