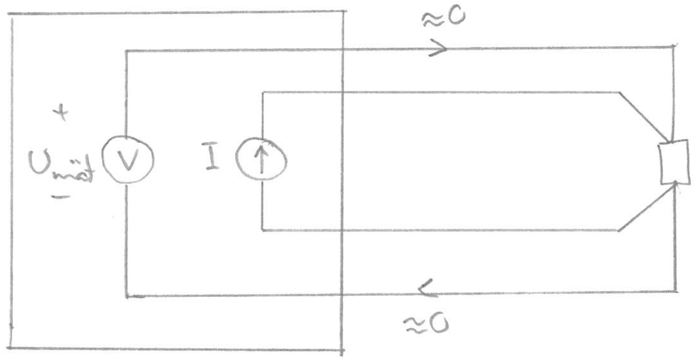
LET271 Elmät Tentamen 2014-08-22

1a) • Mindre termisk brus
• Mindre kapacitiv kopplade störningar

1b)



$U_{mät} = R \cdot I \Rightarrow$

$R_{mät} = \frac{U_{mät}}{I} = R$

Oberoende av kabelresistans

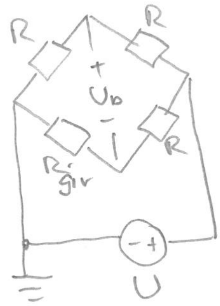
Vid 2-trådsmätning ingår kabelresistans i $R_{mät}$

1c) • Större utsignal
• Kan minska problem med sk "skenbar töjning"

1d) + Linjärare faskarakteristik ⇒ Mindre förvrängning av signal
− Flackare övergång från passband till spärrband

1e) • Jordad skärm
• Större avstånd störkälla till störoffer

2)



$R = 350\,\Omega$

$U = 1{,}2\,V$

$U_b = 0{,}28\,mV$

$k_f = 2{,}09$

$L = 1{,}8\,m$

Kvartsbrygga: $U_b = \frac{1}{4}\frac{dR}{R} \cdot U \Rightarrow$

Relativ resistansändring $\frac{dR}{R} = \frac{4U_b}{U} = \frac{4 \cdot 0{,}28 \cdot 10^{-3}}{1{,}2} = 9{,}33 \cdot 10^{-4}$

Girarfaktor $k_f = \frac{\frac{dR}{R}}{\frac{dL}{L}} \Rightarrow$

Förlängning $\underline{\underline{dL}} = \frac{L}{k_f} \cdot \frac{dR}{R} = \frac{1{,}8}{2{,}09} \cdot 9{,}33 \cdot 10^{-4} = \underline{\underline{0{,}80\,mm}}$

3

Ni-1000 : $R = R_0(1+\gamma T)$ $\Rightarrow$

Referens temp $T_1 = \dfrac{\frac{R}{R_0} - 1}{\gamma} = \dfrac{\frac{1300}{1000} - 1}{6{,}75 \cdot 10^{-3}} = 44°C$

Termoelement $U = E_{AB}(T_2 \to 0°) - E_{AB}(T_1 \to 0°)$

Ur tabell $E_{AB}(T_1 \to 0°) = E_{AB}(44° \to 0°) = 1{,}78\ mV$

$E_{AB}(T_2 \to 0°) = U + E_{AB}(T_1 \to 0°) = 3{,}0 + 1{,}78 = 4{,}78\ mV$

Ur tabel $\underline{\underline{T_2 = 111°C}}$

4

Datainsamlingstid $T = 64\ ms$

Samplingsperiod $T_s = \dfrac{1}{f_s} = \dfrac{1}{250} = 4\ ms$

Datamängd $N = \dfrac{T}{T_s} = \dfrac{64}{4} = 16$

Observationsområde $0 \leq k < \dfrac{N}{2} \Rightarrow 0 \leq k < 8$

"Verklig" frekvens $f = k\dfrac{f_s}{N} = k \cdot \dfrac{250}{16} = k \cdot 15{,}625\ Hz$

Ur tabel $\begin{cases} Y(0) = 2 \\ Y(2) = 3 - j = 3{,}16e^{-j18{,}4°} \end{cases}$

$$\begin{cases} A_0 = \dfrac{Y(0)}{N} \\ A_k = \dfrac{2|Y(k)|}{N} \\ \phi_k = \arg Y(k) \end{cases}$$

k	$\lvert Y(k)\rvert$	A_k	f_k (Hz)	$\phi_k = \arg Y(k)$
0	2	0,125	0	—
2	3,16	0,395	31,25	−18,4°

$\underline{\underline{y(t)}} = A_0 + A_2\cos(2\pi f_2 t + \phi_2) = \underline{\underline{0{,}125 + 0{,}395\cos(2\pi 31{,}25t - 18{,}4°)}}$

2014-08-22

5]

$$\begin{cases} u_{NM} = U_s = 10\,mV \\ u_{CM} \approx u_b = 5{,}0\,V \end{cases}$$

$$u_{UT_{NM}} = 2{,}0\ V$$

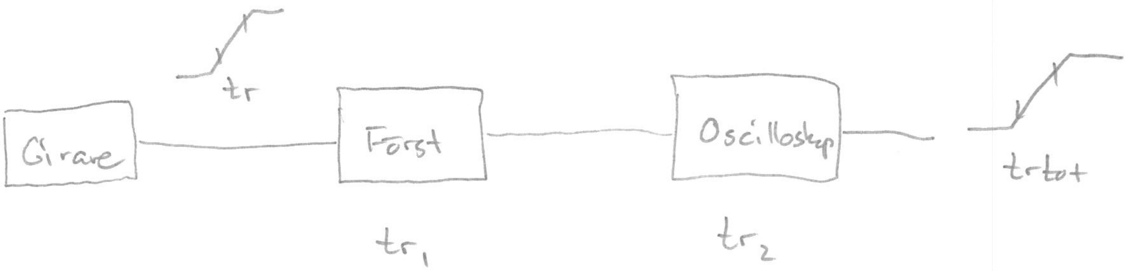
$$\underline{\underline{F_{NM}}} = \frac{u_{UTNM}}{u_{NM}} = \frac{2}{0{,}010} = \underline{\underline{200}}$$

$$u_{UT_{CM}} = 1\% \cdot u_{UT\,NM} = 0{,}01 \cdot 2{,}0 = 0{,}02\ V$$

$$F_{CM} = \frac{u_{UTCM}}{u_{CM}} = \frac{0{,}02}{5} = 0{,}004$$

$$\underline{\underline{CMRR}} = 20\log\frac{F_{NM}}{F_{CM}} = 20\log\frac{200}{0{,}004} = \underline{\underline{94\ dB}}$$

6]



Ur oscilloskopbild: $t_{r_{tot}} = 31{,}9\ ns$

Först. $t_{r_1} = \frac{0{,}35}{BW_1} = \frac{0{,}35}{30 \cdot 10^6} = 11{,}67\,ns$

Oscilloskop $t_{r_2} = \frac{0{,}35}{BW_2} = \frac{0{,}35}{20 \cdot 10^6} = 17{,}5\,ns$

$$t_{r_{tot}}^2 = t_r^2 + t_{r_1}^2 + t_{r_2}^2 \Rightarrow$$

$$\underline{\underline{t_r}} = \sqrt{t_{r_{tot}}^2 - t_{r_1}^2 - t_{r_2}^2} = \sqrt{31{,}9^2 - 11{,}67^2 - 17{,}5^2} = \underline{\underline{24\ ns}}$$

- Exercise 7:

  a) See Figure 1.
  b) It sets the frequency of the waveform to 1000 Hz and its peak-to-peak amplitude to 10.
  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.
  d) See Figure 2.

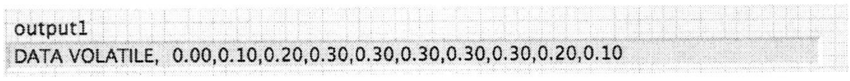


Figure 1: Exercise 7.a

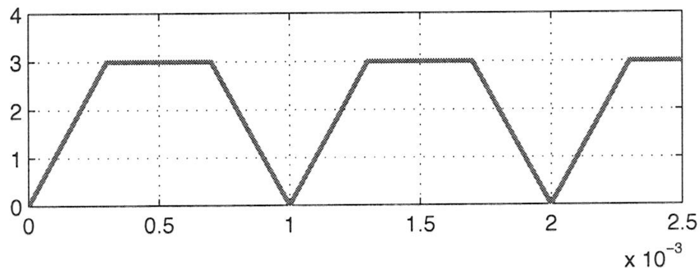


Figure 2: Exercise 7.d

- Exercise 8:

  a) A For loop executes its sub diagram n times, where n is the value wired to the count N terminal. The iteration i terminal provides the current loop iteration count, which ranges from 0 to $n-1$.
  b) See Figure 3.
  c) See Figure 3.
  d) See Figure 3.

- Exercise 9:

  a) See Figure 4.
  b) See Figure 4.
  c) When passing data values into or out of a loop structure, we must create Tunnels where the data values enter and exit the structure. If we enable Auto Indexing, the values that the loop generates will accumulate into an array, which will then be passed from the structure as an array of values. If we simply want to use each individual value in each iteration as they are produced, we need to disable Auto Indexing.

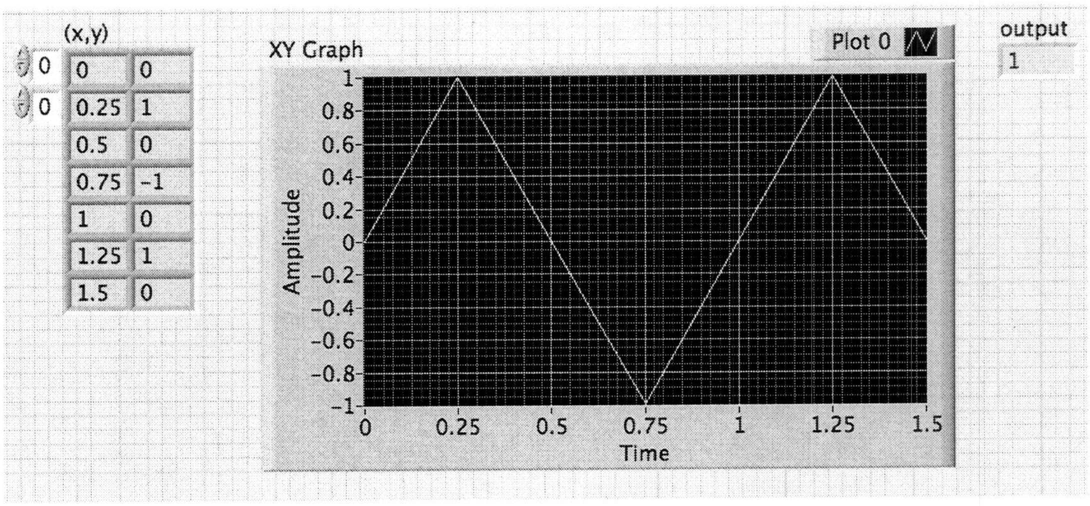
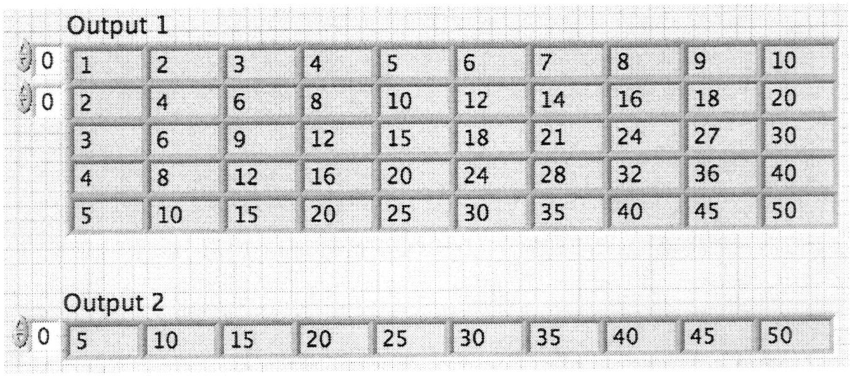


Figure 3: Exercise 8



Output 1

1	2	3	4	5	6	7	8	9	10
2	4	6	8	10	12	14	16	18	20
3	6	9	12	15	18	21	24	27	30
4	8	12	16	20	24	28	32	36	40
5	10	15	20	25	30	35	40	45	50

Output 2

5	10	15	20	25	30	35	40	45	50

Figure 4: Exercise 9

- Exercise 10:

  a) $V = 0.500\,020\,\text{V}$

  b) The standard deviation is $s(V) \approx 21.7 \times 10^{-6}\,\text{V}$; hence, $u_A(V) = s(V)/\sqrt{6} \approx 8.87 \times 10^{-6}\,\text{V}$

  c) The extreme points of the 95% confidence interval are $0.500\,020 \pm 2.57 \times 0.000\,009 = 0.500\,020 \pm 0.000\,023$. So the 95% confidence interval is $[0.499\,997, 0.500\,043]$.

  d) Solution according to GUM:

  $$u_B(V) = \frac{1}{\sqrt{3}}\left(0.500\,020 \times 14 \times 10^{-6} + 2 \times 10^{-6}\right) \approx 9 \times 10^{-6}\,\text{V}.$$

  Hence,

  $$u(V) = \sqrt{u_A^2(V) + u_B^2(V)} = 12.6 \times 10^{-6}\,\text{V}.$$

  The solution where the type-B errors on the reading and on the range are treated separately (book solution) is also acceptable.

  e)

  $$I = \frac{V}{R} = 5.000\,020 \times 10^{-3}\,\text{A}.$$

f) $u(R) = (1/\sqrt{3})0.06\,\Omega = 3.464 \times 10^{-2}\,\Omega$. Now we compute the sensitivity coefficients:

$$c_V = \frac{\partial I}{\partial V} = \frac{1}{R} = 0.01\,\mathrm{V}^{-1}$$

$$c_R = \frac{\partial I}{\partial R} = -\frac{V}{R^2} = 5 \times 10^{-5}\,\mathrm{V}\,\Omega^{-2}.$$

Finally,

$$u(I) = \sqrt{(c_V u(V))^2 + (c_R u(R))^2} = 1.74 \times 10^{-6}\,\mathrm{A}.$$