

i Cover Sheet December 2021

Department of Physics

Examination paper for TFY4185 Measurement Technique / Måleteknikk

Examination date: 17 December 2021

Examination time (from-to): 09:00-13:00

Permitted examination support material: All support material is allowed

Academic contact during examination: Patrick Espy

Phone: +47 73 55 10 95

Technical support during examination: Orakel support services:

Link: innsida.ntnu.no/wiki/-/wiki/English/Orakel+Support+Services

Phone: +47 73 59 16 00

OTHER INFORMATION

Only contact academic contact in case of errors or insufficiencies in the question set.

Saving: Answers written in Inspira are automatically saved every 15 seconds. If you are working in another program remember to save your answer regularly.

Cheating/Plagiarism: The exam is an individual, independent work. *Examination aids are permitted.* All submitted answers will be subject to plagiarism control. Read more about cheating and plagiarism here: innsida.ntnu.no/wiki/-/wiki/English/Cheating+on+exams

Notifications: If there is a need to send a message to the candidates during the exam (e.g. if there is an error in the question set), this will be done by sending a notification in Inspira. A dialogue box will appear. You can re-read the notification by clicking the bell icon in the top right-hand corner of the screen. All candidates will also receive an SMS to ensure that nobody misses out on important information. Please keep your phone available during the exam.

Weighting: *Each correct answer is weighted 4 points. Each incorrect or blank answer is 0 points. Answers are not necessarily exact. You must choose the best or closest answer.*

ABOUT SUBMISSION

Your answers will be submitted automatically when the examination time expires and the test closes, if you have answered at least one question. This will happen even if you do not click "Submit and return to dashboard" on the last page of the question set. You can reopen and edit your answer as long as the test is open. If no questions are answered by the time the examination time expires, your answers will not be submitted.

Withdrawing from the exam: If you wish to submit a blank test/withdraw from the exam, go to the menu in the top right-hand corner and click "Submit blank". This **can not** be undone, even if the test is still open.

Accessing your answer post-submission: You will find your answer in Archive when the examination time has expired.

i Information about the exam

Other information:

All questions are 4 points for correct answer, 0 for incorrect or blank answer

Answers may not be exact, so **choose the best answer**

The course will be graded pass/fail (bestått/ikke bestått).

This year, in accordance with advice from the NTNU administration, the pass level for the course will be set at the E-level or above. That is, 41% or better will be a pass. You will have to pass both the laboratory section as well as this exam to receive a pass for the course.

i Logic Help Sheet

Help pages

Boolean identities

AND function

$$\begin{aligned}0 \cdot 0 &= 0 \\0 \cdot 1 &= 0 \\1 \cdot 0 &= 0 \\1 \cdot 1 &= 1 \\A \cdot 0 &= 0 \\0 \cdot A &= 0 \\A \cdot 1 &= A \\1 \cdot A &= A \\A \cdot A &= A \\A \cdot \bar{A} &= 0\end{aligned}$$

OR function

$$\begin{aligned}0 + 0 &= 0 \\0 + 1 &= 1 \\1 + 0 &= 1 \\1 + 1 &= 1 \\A + 0 &= A \\0 + A &= A \\A + 1 &= 1 \\1 + A &= 1 \\A + A &= A \\A + \bar{A} &= 1\end{aligned}$$

NOT function

$$\begin{aligned}\bar{0} &= 1 \\ \bar{1} &= 0 \\ \overline{\bar{A}} &= A\end{aligned}$$

Boolean laws

Commutative law

$$\begin{aligned}AB &= BA \\A + B &= B + A\end{aligned}$$

Absorption law

$$\begin{aligned}A + AB &= A \\A(A + B) &= A\end{aligned}$$

Distributive law

$$\begin{aligned}A(B + C) &= AB + AC \\A + BC &= (A + B)(A + C)\end{aligned}$$

De Morgan's law

$$\begin{aligned}\overline{A + B} &= \bar{A} \cdot \bar{B} \\ \overline{A \cdot B} &= \bar{A} + \bar{B}\end{aligned}$$

Associative law

$$\begin{aligned}A(BC) &= (AB)C \\A + (B + C) &= (A + B) + C\end{aligned}$$

Note also

$$\begin{aligned}A + \bar{A}B &= A + B \\A(\bar{A} + B) &= AB\end{aligned}$$

Function	Symbol	Alternative symbol	Boolean expression	Truth table															
Buffer			$B = A$	<table><tr><th>A</th><th>B</th></tr><tr><td>0</td><td>0</td></tr><tr><td>1</td><td>1</td></tr></table>	A	B	0	0	1	1									
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OR			$C = A + B$	<table><tr><th>A</th><th>B</th><th>C</th></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>1</td></tr></table>	A	B	C	0	0	0	0	1	1	1	0	1	1	1	1
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i Transistor Help Sheet

BJT parameters for common emitter configuration (subscript _e)

other subscripts: Input_i Output_o Forward_f Reverse_r

h_{FE}	DC gain	I_C / I_B	
h_{fe}	AC gain	i_c / i_b	$h_{FE} \approx h_{fe}$ (mostly)
g_m	Transconductance	$\Delta I_C / \Delta V_{BE} = i_c / v_{be}$	$\sim 40 \cdot I_C \approx 40 \cdot I_E$
h_{ie}	Small signal input resistance	$\Delta V_{BE} / \Delta I_B = v_{be} / i_b$	$\sim 1 / (40 \cdot I_B) \Omega \approx h_{fe} / (40 \cdot I_C)$
h_{oe}	Output admittance (1/ r_o) where r_o = Slope in the active region	$\Delta I_C / \Delta V_{CE} = i_c / v_{ce}$	
r_e	Emitter resistance	$\Delta V_{BE} / \Delta I_C = v_{be} / i_c = 1/g_m$	$\approx v_{be} / i_e$ that is, $h_{ie} = h_{fe} \cdot r_e$
h_{re}	Early effect (V_{CE} affects bias V_{BE})	$\Delta V_{CE} / \Delta V_{BE}$	

$h_{FE} = \frac{I_C}{I_B}$ $I_E = I_C + I_B = (h_{FE} + 1) \cdot I_B$ but because $h_{FE} \gg 1$, $I_E \approx h_{FE} \cdot I_B = I_C$	$I_B = I_{BS} \cdot e^{40 \cdot V_{BE}} \quad \text{where } I_{BS} \text{ is constant}$ $I_C = h_{FE} \cdot I_B = h_{FE} \cdot I_{BS} \cdot e^{40 \cdot V_{BE}}$ $g_m = \frac{\Delta I_C}{\Delta V_{BE}} = \frac{dI_C}{dV_{BE}} = 40 \cdot h_{FE} \cdot I_{BS} \cdot e^{40 \cdot V_{BE}}$ $g_m = \quad \quad \quad = 40 \cdot I_C \approx 40 \cdot I_E$
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