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i Om eksamen

Written home exam in IN1080

2021 Spring

Duration: June 14th 09:00 to June 14th 12:00

It is important that you read this cover page carefully before you start.

General information:

- Important messages during the exam are given directly from the course teacher on the course's semester page or in Canvas (if used in your course). It is therefore important that you check the course's semester page / Canvas room regularly.
- Your answer should reflect your own independent work and should be a result of your own learning and work effort.
- All sources of information are allowed for written home exams. If you reproduce a text from books, online articles, etc., a reference to these sources must be provided to avoid suspicions of plagiarism. This also applies if a text is translated from other languages.
- You are responsible for ensuring that your exam answers are not available to others during the exam period, neither physically nor digitally.
- Remember that your exam answers must be anonymous; do not state either your name or that of fellow students.
- If you want to withdraw from the exam, press the hamburger menu at the top right of Inspera and select "Withdraw".

About the questions:

This exam has multiple choice problems and problems where you are asked to fill in one or several numbers. An incorrect answer will not give a negative score, so you are strongly encouraged to always tick an alternative or write a number even if you are unsure of the correct answer. When entering decimal number, both a point "." and a comma "," will work as a decimal marker. You do not need to use more than one decimal place after comma, and in case the first digit after a comma is a "0", you may simply omit it (Inspera does not distinguish between e.g "9" and "9.0")

Collaboration during the exam:

It is not allowed to collaborate or communicate with others during the exam. Cooperation and communication will be considered as attempted cheating. A plagiarism control is performed on all submitted exams where text similarities between answers are checked. If you use notes that have been prepared in collaboration with others before the exam, this might be detected in a plagiarism control. Such text similarities will be considered an attempt at cheating.

Cheats:

[Read about what is considered cheating on UiO's website.](#)

Contact information: [User support exam](#)

Good luck!

1 **Norton / Thévenin**

Norton / Thévenin

Select one or more alternatives:

- ☐ A Thévenin voltage source is a special type of voltage source which can be used in any circuit, but it is usually more expensive than regular voltage sources
- ☐ A Norton equivalent circuit is only a theoretical aid and in real life one cannot implement such a circuit, even if an ideal current source were available.
- ☐ A current source is only a theoretical aid because all physical sources are only capable of supplying voltages.
- ☐ Replacing the voltage source of a Thévenin equivalent circuit by a current source gives a Norton equivalent circuit
- ☐ En Thévenin spenningskilde er å betrakte som ideell The voltage source of a Thévenin equivalent circuit is considered an ideal source ✓

Maximum marks: 3

2 **Spenningsdeler**

Select one or more alternatives:

- ☐ A voltage divider with a load will also divide the current ✓
- ☐ The output voltage of a voltage divider will drop when the resistance of the load drops
- ☐ Voltage dividers can also be used to increase a voltage
- ☐ The output voltage of a voltage divider designed with two identical resistors with R ohm each and a voltage source giving V_x volts, will give an output voltage of $V_x/2$ when the load resistor has $R/2$ ohm
- ☐ If the input voltage to an ideal voltage source without a load is replaced by an ideal current source, one gets an ideal current source

Maximum marks: 3

3

Elektrisk ladning

Electrical charge

What is the combined charge of 2 electrons?

Select one or more alternatives:

- ☐ -3.28 Ampere
- ☐ -3.28 Coloumb
- ☐ 0C
- ☒ -3.28x10⁻¹⁹C
- ☐ -3.28x10⁻¹⁹ Volt



Maximum marks: 3

4

Spenningskilde

Voltage source

What is the correct statement in case of a practical (i.e. not ideal) voltage source?

Select one or more alternatives:

- ☒ The voltage depends on the current
- ☐ The voltage is 1 Joule when the derivate of the current equals 1 coulomb
- ☐ The current is always constant
- ☐ The voltage is 1 volt when the current equals 1 coulomb
- ☐ The voltage is always constant



Maximum marks: 3

5 **Tidskonstant**

Time constant

Select one or more alternatives:

- ☐ The sum of the resistances and the capacitances of the circuit
- ☒ The point in time where the exponent of the discharge equation equals -1 
- ☐ A measure of the resistance of the circuit
- ☐ The combination of resistance and capacitance giving a charging/discharging time of 37%/63% of the original voltage
- ☐ A measure of the reactance of the circuit

Maximum marks: 3

6 **Ideelle parallellkoblede kondensatorer**

Ideal capacitors connected in parallel

Select one or more alternatives:

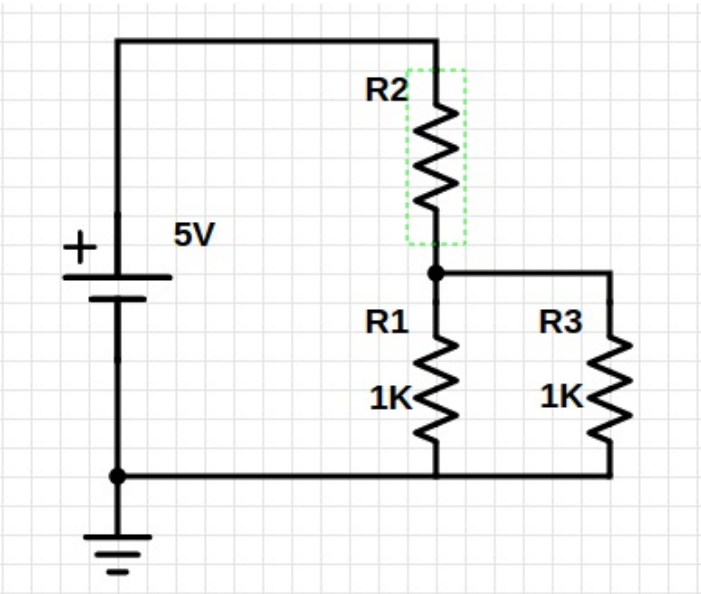
- ☐ The pulse response of a circuit with two identical capacitors connected in parallel equals the pulse response a single capacitor
- ☒ Doubling the plate area of a capacitor yields the same capacitance as the parallel connection of two capacitors each having the capacitance before the plate area is doubled 
- ☐ One usually tries to avoid connection capacitors in parallel due to non-ideal effects
- ☐ The natural response of a circuit with two identical capacitors connected in parallel is identical to the natural reponse of a single capacitor
- ☐ The total reaktance of two identical capacitors connected in parallel equals to twice the reactance of each single capacitor

Maximum marks: 3

7 **Motstandsnettverk**

Resistor network

Find the value of R2 so that the voltage over R3 becomes 3 volts (1K means 1 kOhm)



Skriv et tall: (1.99 - 2.01)kOhm

Maximum marks: 2

8 **Ideelle spoler og RL kretser**

Ideelle spoler og RL kretser

Select one or more alternatives:

- ☐ Inductors and resistors are deigned in the exact same way; the only difference is the winding of the copper wire
- ☒ The reactance of an inductor in an RL circuit will become four times larger if the number of turns is doubled ✓

Man finner induktansen til en parallellkobling av to like spoler på samme måten som man finner resistansen til en serikobling av 2 like motstander The combined inductance of two inductors connected in parallel can be found by using the same way as one finds the resistance of two resistors connected in series

- ☐ The formula for the time constant of an RL circuit is identical to the formula for an RC circuit, except C is replaced by L
- ☐ If one disconnects the voltage from an RL circuit, the inductor will oppose the change in current and maintain the original voltage

Maximum marks: 3

9

Kirchhoff's spenningslov

Kirchhoff's voltage law (KVL)

Select one or more alternatives:

- ☐ All voltages over all closed paths (i.e. loops) of the circuit must be included to obtain 0 as the sum
- ☐ Only the voltages over voltage sources and current sources are added, and not the voltages over passive components
- ☐ Only the voltages over voltage sources are added, not voltages over passive components
- ☐ Current sources which are part of a closed path (loop) are not included when applying Kirchhoff's voltage law
- ☐ The sum of voltages around a single loop will be 0 even if the circuits has several other loops 

Maximum marks: 3

10

Kondensator

Select one or more alternatives:

- ☐ The current through a capacitor is proportional to the total charge stored in it
- ☐ A capacitor conducts more current at low frequencies than at high frequencies
- ☐ The voltage over a capacitor is proportional to the number of electrons which have moved from one of the plates to the other 
- ☐ The current through a capacitor when a square-wave voltage is applied over it, will have phase shift of 90 degrees relative to the voltage
- ☐ The current through a capacitor is created by electrons penetrating the dielectric insulation between the capacitor plates and higher frequencies force more electrons through.

Maximum marks: 3

11 **Konduktans**

Conductance

Select one or more alternatives:

- ☐ The total resistance of two identical resistor R connected in series equals $1/R + 1/R$
- ☒ Conductance designates how well a resistor leads electric current ✓
- ☐ Conductance designates the total resistance of resistors connected in parallel
- ☐ Conductance designates the combined resistance of resistors connected in series
- ☐ The total conductance of two identical resistors R connected in series equals $1/R + 1/R$

Maximum marks: 3

12 **Kirchhoff's strømlov**

Kirchhoff's current law (KCL)

Select one or more alternatives:

- ☐ One cannot apply Kirchhoff's current law and voltage law to a circuit simultaneously
- ☐ Kirchhoff's strømlov gjelder ikke for kretser med RCL komponenter Kirchhoff's current law does not apply to RCL circuits
- ☒ Kirchhoff's current law can also be applied to a circuit where Kirchhoff's voltage law has been applied ✓
- ☐ Kirchhoff's law does not apply to circuits containing open paths
- ☐ Kirchhoff's current law does not apply to circuits with voltage sources

Maximum marks: 3

13

Impedans

Select one or more alternatives:

- ☐ If the area of a capacitor of a simple parallel RC circuit is doubled, the total impedance of the circuit is doubled
- ☐ If the area of a capacitor of a simple parallel RC circuit is doubled, the impedance is cut in two
- ☐ The phase angle of a simple RL circuit is inversely proportional to the time constant
- ☐ The current through a simple serial RC circuit connected to a DC source will be 0 ✓
- ☐ Impedansen i en enkel parallell RL krets er alltid lik impedansen i en enkel parallell RC krets The impedance of a parallel RL circuit is always identical to the impedance of a parallel RC circuit

Maximum marks: 3

14

LED

LED

Select one or more alternatives:

- ☐ LEDs should not be connected directly to ordinary digital outputs of a micro controller; one should use PWM type outputs instead
- ☐ En LED vil blinke hvis den blir koblet til et AC signal der amplituden er større enn diodespenninge~ An LED will pulsate if it is connected to an ac signal higher than the diode voltage ✓
- ☐ The light emission of an LED can be controlled by connecting it directly between a digital output of a micro controller (e.g. an Arduino) and ground
- ☐ Resistors are frequently connected in series with LEDs in order to drive them using square wave signals.
- ☐ An LED will emit roughly the same amount of light irrespective of the direction of the current through it.

Maximum marks: 3

15 **Wheatstone-bridge**

Wheatstone bridge

Select one or more alternatives:

- ☐ The voltage difference between the two outputs of a Wheatstone bridge can never be higher than the supply voltage ✓
- ☐ In a balanced Wheatstone bridge, both output voltages are 0 relative to the negative supply voltage
- ☐ In a balanced Wheatstone bridge, both output voltages have the same value but opposite sign relative to the negative supply voltage
- ☐ A Wheatstone bridge cannot be described by two Norton equivalent voltage sources
- ☐ A Wheatstone bridge cannot be described by two Thévenin equivalent voltage sources

Maximum marks: 3

16 **Transformer**

Select one or more alternatives:

- ☐ Transformatorer brukes ofte til å øke/senke spenningen fra batteri
- ☐ Man kan beregne spenningen ut fra en transformator gitt av spennningen inn og forholdet mellom antall vindinger inn og ut The output voltage of a transformer is given by the input voltage and the number of windings on the input and output side ✓
- ☐ Strømmen gjennom en transformator går gjennom kjernen som trådene er viklet rundt The current through a transformer goes through the core which the copper wire is wrapped around
- ☐ Strømmen ut av en transformator er lik strømmen inn i henhold til Kirchhoffs strømlov The current out of a transformer equals the current into the transformer, according to Kirchhoff's current law
- ☐ En transformator brukes til å omforme AC spenninger til DC spenninger A transformer can be used to convert alternating voltages to direct voltages

Maximum marks: 3

17 Likeretter

Rectifier

Which statement is correct?

Select one or more alternatives:

- ☐ Half-wave rectifiers transfer power from the input to the output less efficiently than a full-wave rectifier ✓
- ☐ A full-wave rectifier will transfer more power from the input signal to the output compared to a bridge rectifier
- ☐ There is no voltage drop on the output of a bridge rectifier due to the barrier voltage of the diodes
- ☐ En fullbølgeretter kan også brukes uten transformator A full-wave rectifier can be used without a transformer
- ☐ Halvbølgerettere egner seg best til å overføre DC signaler fra inngang til utgang Half-wave rectifiers are best suited to transfer dc signals from input to output

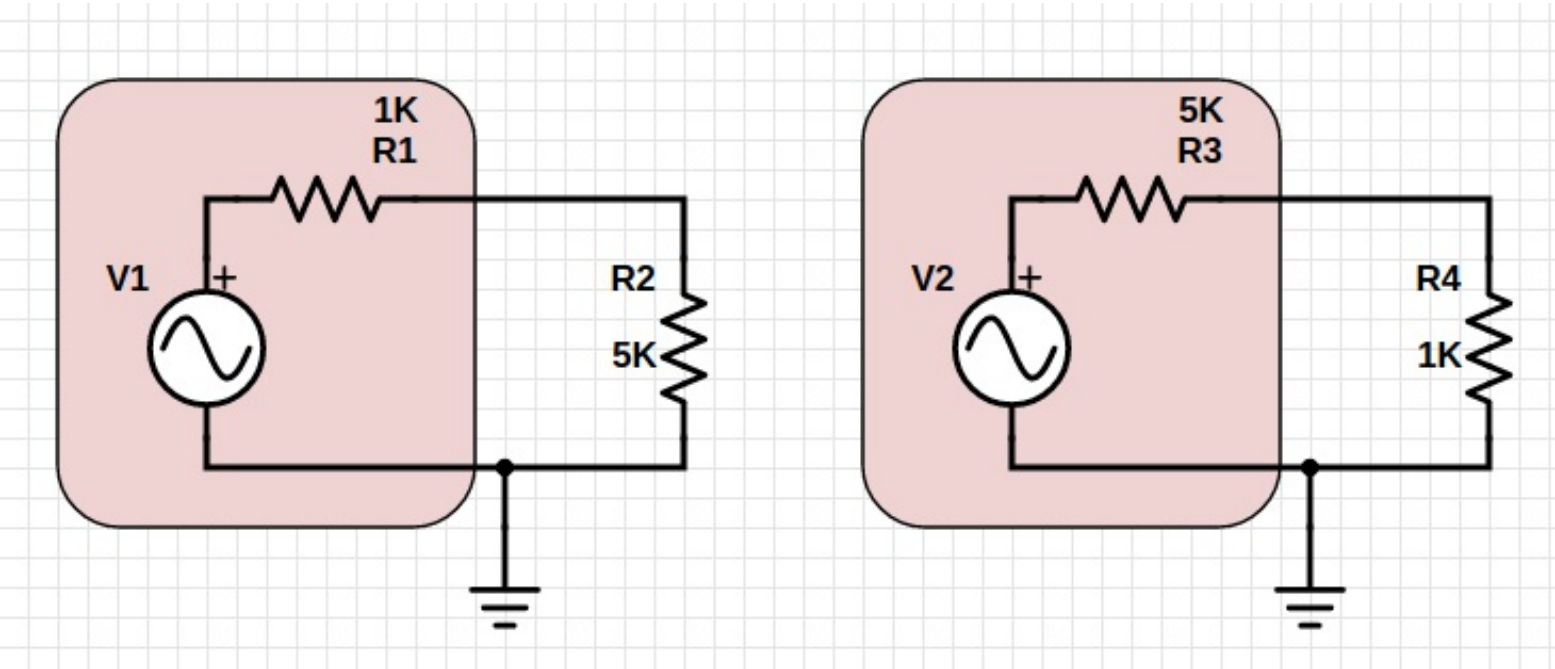
Maximum marks: 3

18 Impedansmatching

Impedance matching

In the drawing below, two signal sources each have an internal Thévenin resistance designated by R1 and R3, whereas the loads are R2 and R4 (1K means 1 kOhm)

Assume equal amplitudes of V1 and V2. Which change in resistor value will increase the transferred power from the signal source to the load the most?



Select one or more alternatives:

- ☐ The amplitude of the voltage sources must be known before determining optimal resistance values
- ☐ Setting R1 = 4.9kOhm
- ☐ Setting R4=0.2kOhm
- ☒ Setting R4 = 6kOhm
- ☐ Setting R1 = 5.1kOhm



Maximum marks: 3

19

Busser

Buses

Given a robot with fifteen servo motors, seven sensor cards and two controller cards. Both controller cards must be allowed to take control of the bus whereas the other cards and the servos operate as slaves. All are to be connected to the same bus using as few wires as possible due to restricted space inside the robot.

What type of bus will be best suited to meet the design constraints?

Select one or more alternatives:

- ☐ I2C
- ☒
- ☐ P2P
- ☐ USB
- ☐ UART
- ☐ SPI

Maximum marks: 3

20

Opamp

Ideell opamp

Select one or more alternatives:

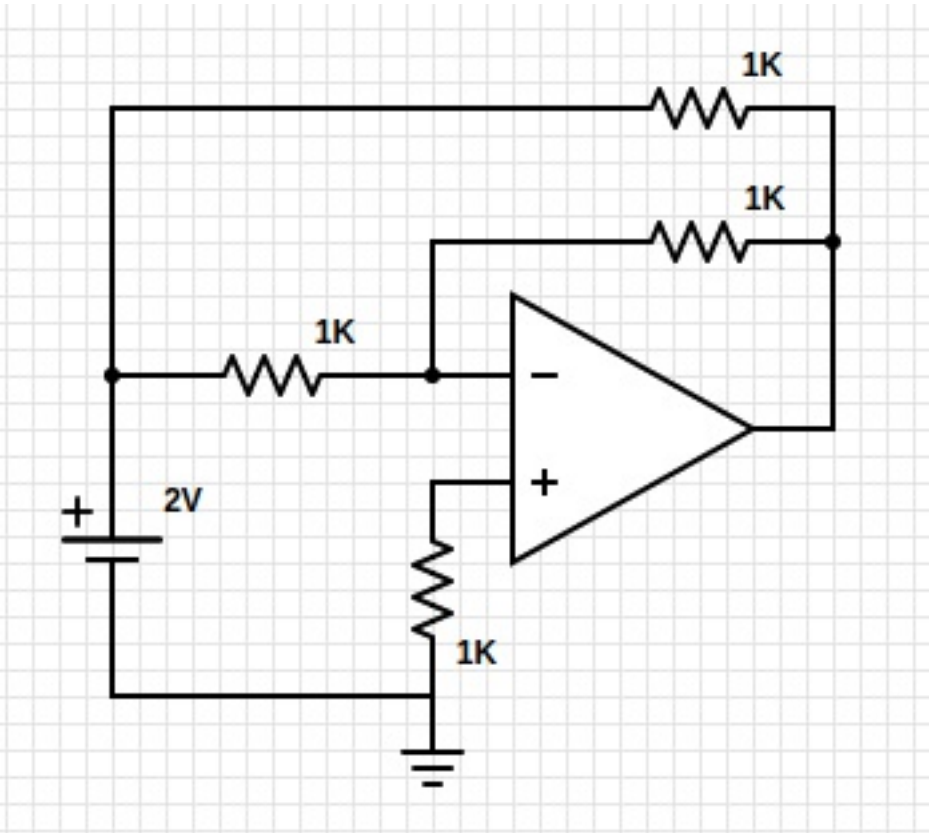
- ☐ The output of an opamp cannot be connected directly to the negative input terminal
- ☐ If the output of an opamp is connected directly to the negative input terminal, one usually gets an output voltage comparable to the voltage on the positive input terminal
- ☒
- ☐ If the output of an opamp is connected directly to the negative input terminal, the output current will equal the current flowing into the positive input terminal
- ☐ If the output of an opamp is directly connected to the negative input terminal, the amplifier circuit will represent the input current as a voltage on the output
- ☐ Kobler man utgangen til en opamp direkte til positiv inngang, får man alltid en spenning ut som er open-loop gain ganger spenningsdifferansen mellom negativ og positiv inngang

Maximum marks: 3

21 Opamp, negativ tilbak kobling

Opamp, negative feedback

What is the output voltage of the opamp (1K betyr 1 kOhm)



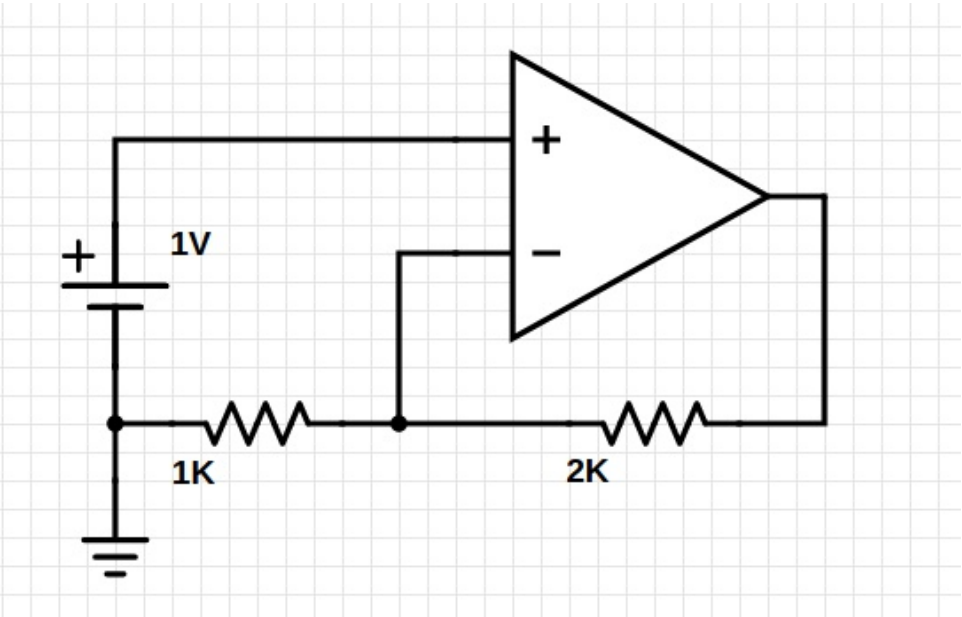
Skriv et tall: (-2.1 - -1.9)volt

Maximum marks: 3

22 Opamp

Opamp

What is the output voltage of the opamp? (1K betyr 1 kOhm)



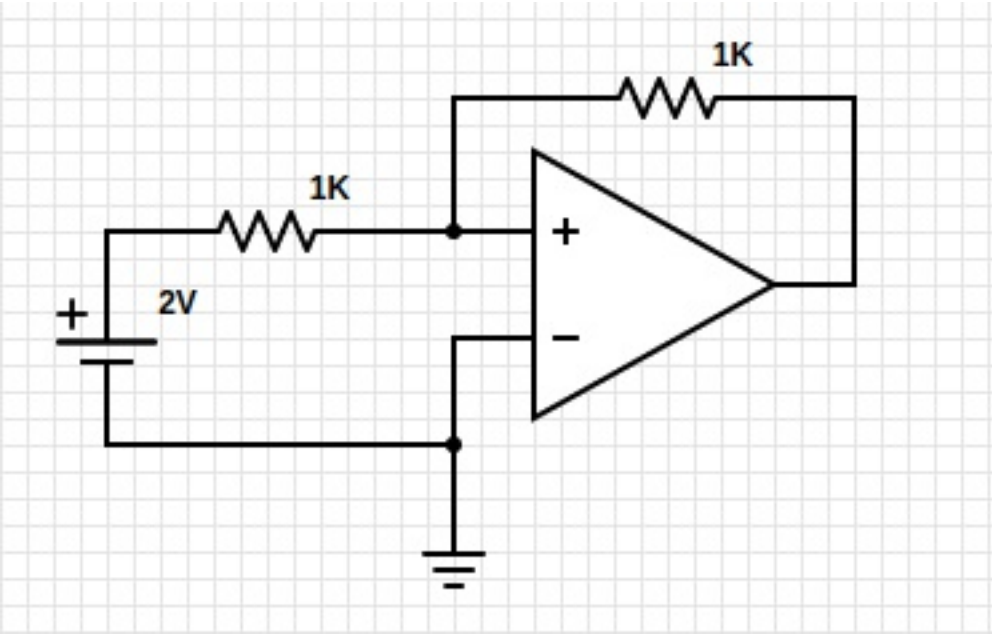
Skriv et tall: (2.5 - 3.5)volt

Maximum marks: 2

23 **Opamp, positiv tilbakekobling**

Opamp, positive feedback

What is the output voltage of the opamp? Hva blir spenningen ut av opampen? (1K means 1 kOhm) Please note that this circuit has positive feedback!



Select one or more alternatives:

- ☐ 1V
- ☐ -2V
- ☒ Close to the supply voltage
- ☐ 2V
- ☐ -1V



Maximum marks: 2

24

H-bru

H bridge

Assume a 5V source for the motor and all digital electronics running at 5V

Select one or more alternatives:

- ☐ An H bridge can basically be designed using only two ordinary inverters plus diodes assuming the transistors are sufficiently powerful. The free running state (high impedance) cannot be met ✓
- ☐ A unipolar step motor can only rotate in one direction at half the torque of a corresponding bipolar step motor.
- ☐ If a step motor needs to be driven in both directions, two H bridges are required. If only one direction is needed, only one H bridge is necessary
- ☐ An H bridge can basically be designed using only two ordinary inverters plus diodes assuming the transistors are sufficiently powerful. The free running state (high impedance) will also be obtained
- ☐ A standard Wheatstone bridge combined with diodes can theoretically drive an ordinary step motor if ultra high resistors are used

Maximum marks: 3

25

Steppermotor

Step motor

Select one or more alternatives:

- ☐ Wave-kommutering gir mange flere mulige vinkler som roteren kan settes i enn ved microstepp
- ☐ kommutering Wave commutation provides many more possible angles for the rotor compared to micro-step commutation
- ☐ How commutation is done does not affect the number of possible angles for the rotor
- ☐ Wave commutation provides the same amount of possible angles for the rotor compared to full-step commutation ✓
- ☐ Wave commutation gives fewer available angles for the rotor compared to full-step commutation
- ☐ Half-step commutation gives fewer available angles for the rotor compared to full-step commutation

Maximum marks: 3

26 **BLDC motor**

BLDC motor

Select one or more alternatives:

- ☐ BLDC motor kommuteres på samme måte som en steppermotor under halvstepp kommutering A BLDC motor is commuted the same way as a step motor under half-step commutation
- ☐ A BLDC motor is commuted the same way as a step motor under full-step commutation
- ☐ A BLDC motor gets current for the coils directly form the output of Hall sensors
- ☒ Theoretically, H bridges can be used to generate the current feeding the coils of a BLDC motor ✓
- ☐ A BLDC motor is commuted the same way as a step motor under wave commutation

Maximum marks: 3

27 **Elektromotor**

Ideal electromotor

Given a DC motor with a coil resistance (R) of 0.5 Ohm and a motor constant (k) of 80 mNm/A. Without load, the motor runs at stable at 400 rad/s.

a) What will the dc voltage of the voltage source have to be under this condition?

Write your answer here: (31,9 - 32,2)Volt

The supply voltage is now set to 20 v

b) What will the rotational speed be in this case?

Write your answer here: (249 - 251)rad/s

The motor is set to do a job which reduces its speed to 10 rad/s. The supply voltage remains constant (20v)

c) What will be the current consumption under this condition?

Write your answer here: (37,9 - 38,5)A

d) What is the torque of the motor? (The load and supply voltage remain the same as in c)

Write your answer here: (3 - 3,1)Nm

This motor will be used to lift a basket with beverages up one floor in a restaurant. It is connected to a drum with a 10 cm radius which winds up a rope lifting the basket. The supply voltage will be 40 V DC. The chef gives the basket a little push as he sends the goods up one floor where the guests are. We ignore the weight of the basket and the rope, as well as friction and the diameter of the rope.

e) What is the maximum weight of the cargo which can be sent in the basket?

Write your answer here: (6 - 7)kg

Maximum marks: 15

28 **AD konvertering**

AD conversion

Assume a 3.3V AD converter with 10-bit precision with a dynamic area rail-to-rail, i.e from 0V til 3.3V. The sampling speed is 1 MHz.

a) How many levels can the AD converter distinguish between?

Write your answer here: (1023 - 1024) levels.

b) What is the minimum voltage difference between to levels?
(Assume linearity over the whole area of operation).

Write your answer here: (3 - 3,5)mV

The AD converter is embedded in a microcontroller and it is used in two ways. Either it samples the input at the highest frequency or it samples all eight inputs A0 to A7 in a fixed sequence. The actual sampling is done at the same fixed frequency.

We wish to connect five sensors to the AD converter.

c) What is the maximum frequency of any input signal of the five sensors without experiencing aliasing?

Write your answer here: (62 - 63)kHz

Imagine an input signal with -40dB noise and assume that the signal uses the whole dynamic area.

d) How many levels of the AD converter does the noise maximally correspond to?

Write your answer here: (10 - 11)levels

Maximum marks: 10