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APRIL EXAMINATION

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N6

(8080186)

4 April 2013 (X-Paper)
09:00–12:00

This question paper consists of 10 pages and a 3-page formula sheet.

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
INDUSTRIAL ELEKTRONICS N6
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

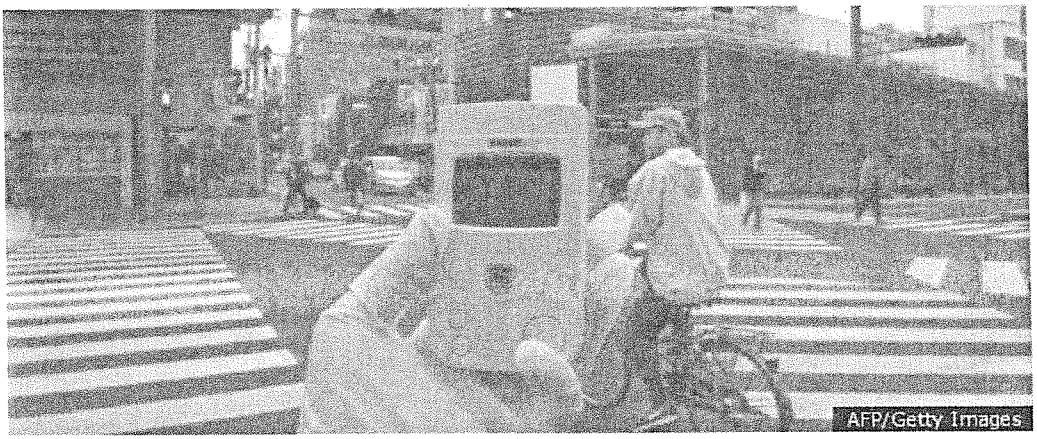
1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Write neatly and legibly.

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QUESTION 1

Read the following abstract and answer the questions.

JAPAN NUCLEAR DISASTER RELEASED HIGHER RADIATION LEVELS THAN PREVIOUSLY REPORTED, STUDY FINDS



NEW YORK — The Fukushima nuclear disaster released twice as much radioactive substance into the atmosphere as Japanese authorities had previously estimated. It could be as much as 40% of the total amount released by the Chernobyl disaster, a preliminary report says.

The estimate of much higher levels of radioactive cesium-137 comes from a worldwide network of sensors. Andreas Stohl of the Norwegian Institute for Air Research says the Japanese government estimate came only from data in Japan, and that would have missed emissions blown out to sea.

The study did not consider health implications of the radiation. Cesium-137 is dangerous because it can last for decades in the environment, releasing cancer-causing radiation.

The long-term effects of the nuclear accident are unclear because of the difficulty of measuring radiation amounts people received …

[Adapted from: *The Huffingtonpost.com*]

1.1 From the passage above it is clear that during such a disaster, radioactive substances are released extensively into the atmosphere.

Name THREE common types of radioactive isotopes. State the charge as well as the penetrating abilities of each. (6)

1.2 Which ONE of the abovementioned particles is most harmful to the human body and what biological effects will it have on the body should there be high levels of exposure, either rapid or slow? (3)

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1.3 The severity of the effects mentioned in your answer to QUESTION 1.2 depends on a number of factors, like the type of radiation, the dose absorbed and the rate at which exposure took place.

What precautionary measures need to be taken in general when working with radioactive materials? (5)

1.4 The biochemist in the picture on page three is checking the radiation levels at a specific location. The detector he is holding can be any one of four devices commonly used.

1.4.1 Name the ONE you think he is using and make a detailed, labelled sketch of it. (3)

1.4.2 Give a brief description of the operation of the detector you named and sketched in QUESTION 1.4.1. (3)
[20]

QUESTION 2

Read the abstract below and answer the questions.

MINISTER'S NEPHEW IMPLICATED IN HIJACKING

A relative of Police Minister Nathi Mthethwa was arrested recently in connection with the hijacking of a policeman in a Durban suburb.

Maga Musa Artwell (33), Mthethwa's nephew, made a brief appearance in the Durban magistrate's court and was remanded in custody.

He is alleged to have hijacked the Mercedes Benz Vito of a policeman, Colonel Els's, from his driveway.

It is alleged that Els was opening his garage door when the group of hijackers struck.

[Adapted from: *www.iol.co.za/news/crime-courts/minister-s-nephew-implicated-in-hijacking-1.1281230*]

2.1 The abovementioned incident could have been avoided if it had not been necessary for Col Els to get out of his vehicle to open the garage door.

Design an elementary automatic garage door opener that opens the door once the remote button is pressed. When the upper limit switch is triggered, the door has to stop for a predetermined time of 15 seconds and then close again. The door must also stop when the lower limit switch is triggered.

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NOTE:

- Your program must include a main contactor that should be able to isolate the circuit for a routine service and maintenance program.
- The remote button contains an emergency stop button which must also be incorporated in your design.
- Should any emergency occur, the program will automatically reset itself and then the scan procedure will return to rung 1 awaiting new instructions. (You do not need to include the last condition in your design, as it will automatically be restored.)
- You may use any element required for your design, like n/o contacts, n/c contacts, timers, output coils and limit switches, but it should be limited to the requirements of a PLC logic ladder diagram design. (10)

2.2 On your way home from work you receive an sms from your security company, informing you of a power failure at your residence. Luckily you have installed a UPS that is suitable for office or domestic use only a few months ago because there is valuable information on your computer that needs to be sent to an insurance company regarding a claim that you submitted recently.

Draw a fully labelled block diagram of the UPS that enables you to access your computer in the event of a power failure. (10)

2.3 On arriving home, you notice a red light on your UPS indicating low-output voltage. You contact the technician for help, on which he confirms your suspicion by informing you that the problem lies with the battery charger. He requests you to open the UPS and e-mail him the labelled circuit diagram of the rectifier printed inside the lid that covers the UPS.

2.3.1 Draw a labelled circuit diagram of the uncontrolled full-wave bridge rectifier printed inside the lid that covers the UPS that you are going to mail to the technician. (4)

2.3.2 The technician also needs the mean output voltage of the battery charger. Unfortunately the voltage information he requires cannot be located and you have to calculate it. Assume silicon diodes with a 0,6 volt drop per diode are used in the bridge rectifier.

The following specifications appear on the back of the lid:

- Input voltage = 250 V
- Step-down transformer with ratio 16 : 1
- Low power battery charger supplies 153 W, 9,8 A

Now calculate the mean output voltage feeding the batterybank as requested by the technician. (6)
[30]

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QUESTION 3

Study the scenario below and answer all the questions. Keep in mind that the scenario and all that follows have to be used or might have an influence on the rest of the questions.

As a design engineer of a fast-growing electronic company, you need to design a RL circuit that is able to deliver an output current which will then be modified for a specific application by a current-to-voltage interfacing network.

Sources/Instruments/Data available:

- An oscilloscope
- A 230 V DC source
- A relay coil that requires a time constant of 0,0015 seconds and enables the current to reach 175 mA during this charging period

Before you can design anything you need to look at the behaviour of the voltage and branch current during this transitional interval.

3.1 Clearly show, with THREE different sketches, the waveforms of the following charge/discharge cycles that will be displayed on the oscilloscope:

3.1.1 Voltage across inductor (V_L) versus time (t) (2)

3.1.2 Voltage across resistor (V_R) versus time (t) (2)

3.1.3 Current (i) versus time (t) (2)

3.2 Next you need to design the coil of the RL circuit as requested in the information given to you.

To accomplish this, you need to calculate the following:

3.2.1 The final (maximum) value of the current in the circuit (3)

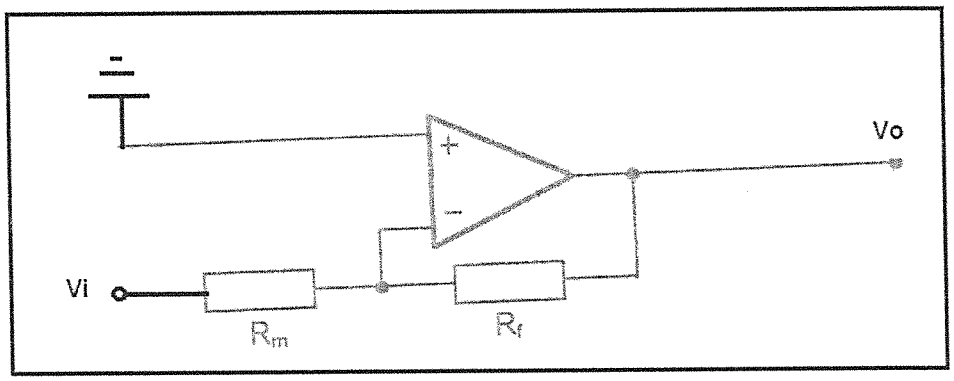
3.2.2 The resistance value (3)

3.2.3 The inductance value of the coil (3)

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3.3 The output current that you have worked out, irrespective of the value, now needs to be modified by a current-to-voltage interfacing network to obtain an appropriate voltage which will then be used as an input voltage in the final stage where further conditioning/excitation or amplification needs to take place.

3.3.1 Identify the circuit below that is required in the final stage for further conditioning/excitation/amplification:



(1)

3.3.2 The voltage obtained from the current-to-voltage interfacing network during the modification process is modified to supply a square-wave pulse train which is clamped at 0 V and has a maximum positive value of 500 mV. This voltage is now fed to the network you identified in QUESTION 3.3.1.

Assume no gain nor any loss of the network in QUESTION 3.3.1 and draw the output waveform that is shown on the oscilloscope during the abovementioned final stage network. (3)

3.3.3 Use all the data and information obtained in QUESTION 3.3.1 and QUESTION 3.3.2 and assume a gain of 10 and a metering resistor value of 1 kΩ to calculate the following:

(a) The value of the feedback resistor (3)
(b) The output voltage of the network (3)
[25]

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QUESTION 4

Complete COLUMN A by filling in the missing word(s). Then match the words you filled in at each question number with the appropriate application in COLUMN B. Write only the missing word(s) and the letter of the application (A–S) next to the question number (4.1.1–4.8.2) in the ANSWER BOOK. Your answer might look like one of the following two examples:

Example 4.1.1 Answer–Y

4.2.1 Answer
4.2.2 Answer } Z

COLUMN A		COLUMN B	
4.1	A search coil oscillator and a reference oscillator are tuned to the same (4.1.1) ... without any interference. Once a disturbance is picked up, it results in an output followed by the necessary action to be taken. (2)	A	CAM system prerequisite
		B	straight beam testing
		C	three-way system
		D	metal detector
4.2	Sometimes, minute cracks are too small and cannot be picked up by X-rays. They can be located by using (4.2.1) ... . One method is when the transmitted signal and reflected signal are (4.2.2) ... with each other so that strengthening of the signal occurs. (3)	E	loop concept
		F	plugging
		G	circuit evaluation
		H	watch-dog timer
4.3	During the manufacturing process the product is checked for conformity to specifications. If any deviation occurs, the product is (4.3.1) ... to the production line to be reworked or to be scrapped. (2)	I	series shunt protection
		J	numeric control
		K	positive protection
4.4	In an industrial punch press, safety plays a prominent role. The punch will only operate once the operator's hands do not interfere with the light beam and the foot control is pressed down while one hand presses the safety switch and the other hand operates the 'Punch Press Down' button. When all these safety conditions are (4.4.1) ... fulfilled it is expressed by a (4.4.2) ... function. (3)	L	two-way system
		M	stand-alone programmer
		N	regenerative braking
		O	universal language
		P	resonance testing
4.5	It refers to equipment and wiring that are incapable of releasing sufficient electrical energy under (4.5.1) ... or (4.5.2) ... conditions to cause ignition of any specific hazardous atmospheric mixture. (3)	Q	communication interface
		R	intrinsic safety
		S	open-loop operation

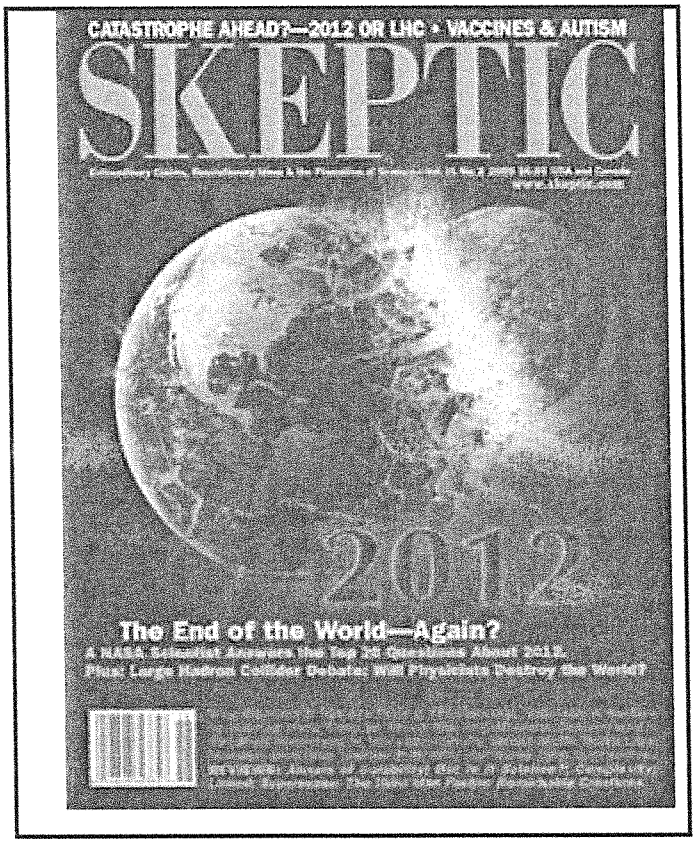
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4.6	In the manufacturing environment the central computer needs to communicate with many devices. Unfortunately, two-way communication is needed but the central computer can only 'listen' to one peripheral or device at a time. To achieve this, the system uses (4.6.1) ... . Above description is known as (4.6.2) ... (3)	
4.7	AC motor speed control can be achieved in a number of ways. One specific application is to remove the motor's supply, thereby turning the (4.7.1) ... into a (4.7.2) ... and returning the energy to the DC source. (3)	
4.8	To ensure reliable operation of the central processing unit a self-test of its internal operation is done by a specific circuit. This circuit ensures the CPU not to enter an endless loop because of (4.8.1) ... This circuit will shut the CPU off should the (4.8.2) ... exceeds a certain predetermined time. (3)	

[22]

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QUESTION 5



When we look at the ever-changing technology as it advances from switchboard telephones to cellphones, from log tables to iPads, from man trying to fly with man-made wings to space shuttles discovering new galaxies, and you consider the danger of global warming, it seems that we are on the brink of either another ice-age or the end of the world.

Do you regard this statement as a reality or a far-fetched fantasy? State your opinion in not more than 50 words.

Structure your answer using the framework below.

5.1 I think that … (1)

5.2 The evidence to support this idea is … (1)

5.3 Arguments against me are … (1)
[3]

TOTAL: 100

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INDUSTRIAL ELECTRONICS N6

$A = B \cdot \left(1 - e^{-t/\tau}\right)$

$A = B \cdot e^{-t/\tau}$

A = Instantaneous value and

B = Maximum value

$V = E \cdot \left(1 - 2e^{-t/\tau}\right) = I \cdot R$ *volts*

$V_D = V_S \left(\frac{R_1}{R_1 + R_2} - \frac{R_3}{R_3 + R_{TH}} \right)$ *volts*

$V_i = \frac{I_L \cdot R_1 \cdot R_D}{R_2} = -\frac{V_o \cdot R_1}{R_2} = \frac{V_o \cdot R_M}{R_M + R_f}$ *volts*

$V_o = -RC \cdot \frac{dV_i(t)}{dt} = -\frac{1}{RC} \int V_i(t)\, dt + V_C(0)$ *volts*

$V_o = \frac{R_2 R_D I_i}{R_1} = -\left[\frac{V_1 R_f}{R_1} + \frac{V_2 R_f}{R_2} + \frac{V_3 R_f}{R_3} + \ldots \right]$ *volts*

Supply rating = Voltage per stage × Number of stages *volts*

$V_{\max} = \sqrt{2} \times V_{rms}$ *volts*

$V_{mean} = 0{,}637 \times V_{\max} = \frac{0{,}637}{2} \times V_{\max}$ *volts*

$V_{mean} = \frac{3 \cdot \sqrt{2}}{\pi} V_{line}$ *volts*

$V_{mean} = \frac{\sqrt{2}}{2 \cdot \pi} V_{rms} \times (1 + Cos\ \alpha)$ *volts*

$V_{mean} = \frac{\sqrt{2}}{\pi} V_{rms} \times (1 + Cos\ \alpha)$ *volts*

$V_{mean} = \frac{2 \cdot \sqrt{2}}{\pi} V_{rms} \times Cos\ \alpha$ *volts*

$V_{mean} = \frac{3 \cdot \sqrt{3}\sqrt{2}}{2\ \pi} V_{per\ phase} \times (1 + Cos\ \alpha)$ *volts*

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$V_{mean} = \frac{3 \cdot \sqrt{2}}{\pi} V_{line} \times Cos\ \alpha$ *volts*

$V_{line} = \sqrt{3} \times V_{per\ phase}$ *volts*

$V_{\max} = \sqrt{2} \times V_{line} = \sqrt{2} \times V_{rms}$ *volts*

$I_{rms} = \frac{\sqrt{2}}{2} I_{\max}$ *amps*

$I_{rms} = \frac{\sqrt{2}}{3} I_{\max}$ *amps*

$I_{rms} = \frac{0{,}707}{2} \times I_{\max}$ *amps*

$I_{rms} = I_{peak} \times \sqrt{\frac{\phi}{2 \cdot \pi}}$ *amps*

$I_{peak} = \frac{I_{mean}}{\phi} \times 2\pi$ *amps*

$I_{tube} = Number\ of\ electrons\ per\ second \times q$ *amps*

$I_{max} = Maximum\ safe\ illumination \times Tube\ sensitivity$ *amps*

$Sensitivity = Cathode\ sensitivity \times A$ *amps/lumen*

$P = I^2 \cdot R = V \cdot I = V^2 / R$ *watts*

$X\text{-}ray\ power = P_T \times \eta$ *watts*

$Dissipated\ power = P_T - Power\ used$ *watts*

$\triangle R = R_{TH} \times \triangle t \times temperature\ coefficient$ *ohms*

$Z_{TH} = \frac{T_{rise}}{T_{loss}}$ *ohms*

$R = \frac{T_1 - T_2}{P} = \frac{L}{\tau}$ *ohms*

$f = \frac{1}{t} = \frac{c}{\lambda} = \frac{\omega}{h} = \frac{\omega}{2\pi} = \frac{E \times q}{h}$ *hertz*

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$$f_r = \frac{1}{2\pi \times \sqrt{LC}}$$ *hertz*

$$f_n = \frac{1}{2\pi} \times \sqrt{\frac{1}{LC} - \left(\frac{R}{2L}\right)^2}$$ *hertz*

$\int^n$ = *Amplification* *hertz*

$$\int = \frac{\pi \cdot R}{\omega \cdot L}$$

$$C = \frac{t}{R_L} = \frac{\tau}{R}$$ *farads*

$$d = \frac{v \cdot t}{2}$$ *metres*

$$\omega = 0{,}5 \times C \times V^2 = 0{,}5 \times L \times I^2$$ *joules*

$$q = \frac{h \cdot v}{E \cdot \lambda}$$ *coulombs*

$$n = t \times f = 1 + \frac{\ln 100}{\int}$$ *number of oscillations*

$$\eta = 1{,}4 \cdot 10^{-9} \times E \times Z$$ *per unit*

$$°C_{\max} = V_{i\max} \div V/°C$$ *Celsius*

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