NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT

Benodigdhede vir hierdie vraestel/Requirements for this paper:			
Antwoordskrifte/ Answer scripts:	X	Multikeusekaarte (A5)/ Multi-choice cards (A5):	
Presensiestrokies (Invulvraestel)/ Attendance slips (Fill-in paper):		Multikeusekaarte (A4)/ Multi-choice cards (A4):	
Rofwerkpapier/ Scrap paper:		Grafiekpapier/ Graph paper:	

Sakrekenaars/Calculators:	Ja/Yes
Ander hulpmiddels/Other resources:	

Tipe Assessering/ Type of Assessment:	Eksamen 1e geleentheid Exam 1st opportunity Vraestel/Paper 1	Kwalifikasie/ Qualification:	B.ING
Modulekode/ Module code:	EERI 423	Tydsduur/ Duration:	3 uur 3 hour
Module beskrywing/ Module description:	TELEKOMMUNIKASIE	Maks/ Max:	100
Eksaminator(e)/ Examiner(s):	PROF JEW HOLM	Datum/ Date:	9/11/2016
Moderator(s):	MNR CHRISTO VAN DER MERWE (INTERN) MNR CARL THOM (EKSTERN)	Tyd/ Time:	09:00

Inhandiging van antwoordskrifte/Submission of answer scripts: **Gewoon/Ordinary**

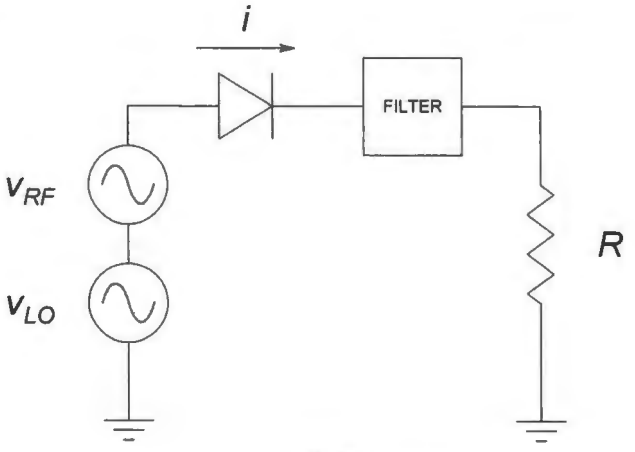
Vraag 1: Algemene vrae / Question 1: General questions [9]

1.1 Teken die basiese elemente van enige kommunikasiestelsel – benoem elke element. */ Draw the basic elements of any communication system – name each element.* [4]

1.2 Teken die diagram van 'n eenvoudige fasesluitlus (PLL) sintetiseerder – benoem elke element. */ Draw the block diagram of a basic phase-locked loop (PLL) synthesizer – name each element.* [5]

Vraag 2: Versenders en ontvangers / Question 2: Transmitters and receivers [34]

2.1 Verduidelik wiskundig hoe 'n kwadraatwet menger 'n IF sein kan genereer van RF en LO seine deur te verwys na die diagram onder – dui aan watter seine behou word, en watter seine uitgefilter word. */ Give a mathematical description how a square law mixer generates an IF signal by referring to the diagram below – show which signals are retained and which signals are filtered out.* [9]



$$v_{RF}(t) = \cos(\omega_{RF} t) \qquad v_{LO}(t) = \cos(\omega_{LO} t)$$

2.2 'n Ontvanger met 'n 75 Ω insetimpedansie werk by 'n temperatuur van 290 K. 'n RF sein word ontvang met 'n bandwydte van 25 kHz. Die seinvlak by die ontvanger is 1 μV_{RMS} en die ontvanger het 'n saamgestelde ruistal van 3.5 dB. / *A receiver with a 75 Ω input impedance works at a temperature of 290 K. A signal is received with a bandwidth of 25 kHz. The signal level at the receiver is 1 μV_{RMS} and the receiver has a noise figure of 3.5 dB.*

(a) Bereken die ruisdrywing. / Calculate the noise power. [2]
(b) Bereken die seindrywing. / Calculate the signal power. [2]
(c) Wat is die sein-tot-ruis verhouding voor die ontvanger? / What is the signal-to-noise ratio before the receiver? [2]
(d) Wat is die sein-tot-ruis verhouding by die uitset van die ontvanger? / What is the signal-to-noise ratio at the output of the receiver? [2]

2.3 Dui aan die hand van 'n skets die beginsel van 'n beeldfrekwensie aan. Watter oplossings bestaan om beeldfrekwensies aan te spreek – noem 3. / *Show by means of a sketch the principle of an image frequency. What solutions exist to address image frequencies – name 3.* [7]

2.4 Teken die blokdiagram van 'n moderne, direkte-omskakeling ontvanger. Benoem elke element duidelik. / *Draw the block diagram of a modern, direct-conversion receiver. Clearly name each element.* [10]

Vraag 3: Kommunikasiestelsels / Question 3: Communications systems [18]

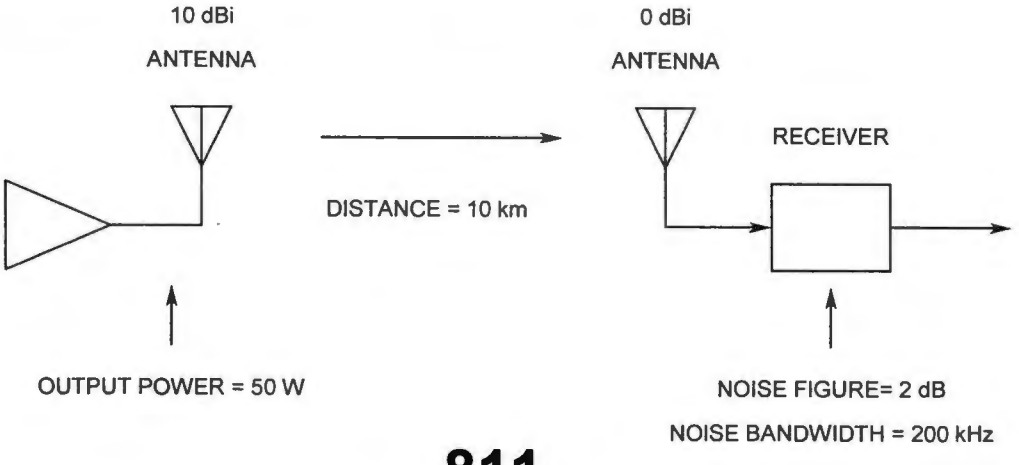
3.1 Beantwoord die volgende vrae: / *Answer the following questions:*

(e) Verduidelik kortliks die verskil tussen Tyd-deel-dupleksering (TDD) en Frekwensie-deel-dupleksering (FDD). / *Briefly explain the difference between Time-division-duplexing (TDD) and Frequency-division-duplexing (FDD);* [2]
(f) Hoe is dit moontlik om 'n hoër bistempo oor 'n kanaal te stuur as wat die bandwydte van die kanaal is – verduidelik aan die hand van die Shannon-Hartley vergelyking. / *How is it possible to transmit data at a higher bit rate than the bandwidth of the channel – explain with reference to the Shannon-Hartley equation?* [4]
(g) Verduidelik (kortliks) die gebruik van 'n deiningsmarge in 'n kommunikasiestelsel. / *Explain (briefly) the use of a fading margin in a communication system.* [2]
(h) Waarom is LTE so 'n robuuste kommunikasiemetode (verwys na antennes en multipleksering)? / *Why is LTE such a robust communication method (refer to antennas and multiplexing)?* [2]

3.2 Voorsien 'n blokdiagram van 'n QPSK demodulator – benoem elke element duidelik. / *Provide a block diagram of a QPSK demodulator – clearly name each element.* [8]

Vraag 4: Drywingsbegroting / Question 4: Power budget [14]

'n Versender en ontvanger het die volgende komponente met winste en verliese soos aangedui, beantwoord die vrae wat daarna volg: / *A transmitter and receiver have the following components with gains and losses as indicated, answer the questions that follow:*



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- Log-afstand padmodel / *Log-distance path model*;
- PL(d0): 30 dB by 1m / *at 1m;*
- Padverlieskonstante / *Path loss constant:* 2.6;
- Deiningsmarge / *Fading margin:* 30 dB.

Beantwoord die volgende vrae: / *Answer the following questions:*

(i) Bereken die padverlies. / *Calculate the path loss.* [2]
(j) Toon aan dat die sein-tot-ruis (S/N) na die ontvanger 12 dB is wanneer die deiningsmarge en ruistal in ag geneem word (bereken die minimum detekteerbare sein). / *Show that the signal-to-noise (S/N) after the receiver will be 12 dB when the fading margin and noise figure are taken into account (calculate the minimum detectable signal).* [7]
(k) Wat is die teoretiese maksimum bistempo van die stelsel? / *What is the theoretical maximum bit rate of the system?* [3]
(l) Hoeveel bisse is nodig indien 'n komplekse modulasieskema gebruik word? / *How many bits are required if a complex modulation scheme is used?* [2]

Vraag 5: Sellulêre stelsel beginsels / Question 5: Cellular system principles [25]

'n Sellulêre stelsel word aan Pofadder voorsien. Die volgende is bekend: / *A cellular system is provided to Pofadder. The following is known*:

- Aanvanklike aantal gebruikers = 8,000 / *Initial number of users = 8,000*
- Daar is aanvanklik 4 selle per bondel ("cluster") / *Initially there are 4 cells per cluster*
- Die aantal bondels ("clusters") bly 10 vir alle berekeninge (interferensie is nie 'n probleem nie) / *The number of clusters remains at 10 for all calculations (interference is not a problem)*
- Blokkering sal aanvanklik gebruik word met 2% oproepe wat geblokkeer en skoongemaak sal word / *Initially call blocking will be used with 2% blocked calls cleared*
- Die huidige diensverskaffer het 90 radiokanale beskikbaar vir spraak, en daar is geen addisionele kanale beskikbaar nie / *The current service provider has 90 radio channels available for voice and there are no additional channels available*
- Gedurende die besige uur bel die gemiddelde gebruiker 2 maal per uur en elke oproep duur 3 minute – hierdie bly konstant ongeag die aantal gebruikers / *During busy hour, the average user calls 2 times per hour with each call lasting 3 minutes – this remains constant regardless of the number of users*
- Die stelsel is onder druk om die netwerk kapasiteit te verhoog na 10,000 gebruikers omdat diamante naby die dorp ontdek is / *The system is under pressure to increase network capacity to 10,000 users as diamonds have been found nearby*

(m) Hoeveel gebruikers kan hanteer word in die besige uur met die stelsel soos bo gedefinieer? / *How many users can be supported in the busy hour with the system as defined above?* [8]
(n) Om die kapasiteit te verhoog, word die opsie oorweeg om die blokkeringswaarskynlikheid te verhoog na 5%. Hoeveel gebruikers kan hanteer word wanneer die aantal selle/bondel 4 bly? / *To increase capacity, the option to increase blocking probability to 5% is being considered. How many users will be supported when the number of cells/cluster remains at 4?* [4]
(o) 'n Ander opsie om netwerk kapasiteit te verhoog is om die aantal selle/bondel na 3 te verlaag. Hoeveel gebruikers kan hanteer word wanneer die blokkeringswaarskynlikheid 2% bly? / *Another option to increase network capacity is to reduce the number of cells/cluster to 3. How many users will be supported if the blocking probability remains at 2%?* [4]

Meer vrae volg op bladsy 4 / *More questions follow on page 4*

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(p) Oorweeg die resultate in (b) en (c) verkry en maak 'n voorstel deur in ag te neem gebruikers se ervaring van diens, implementeringstyd, asook koste van toerusting. / *Consider the results obtained in (b) and (c) and make a proposal by taking into account user experience, implementation time, and cost of equipment.* [3]

(q) 'n Konsultant het later met 'n voorstel gekom om 120° sektorisering te gebruik (N = 4, Pblock = 2%) – sal dit kapasiteit verhoog of verlaag? Steun jou bevinding met berekeninge. / *A consultant later came with a proposal to use 120° sectoring (N = 4, Pblock = 2%) – will this increase or decrease capacity? Support your finding with calculations.* [6]

TOTAAL/TOTAL: 100

EERI423 FORMULEBLAD VIR NOVEMBER 2016
EERI423 FORMULA SHEET FOR NOVEMBER 2016

Ontvangers, versenders en ruis / *Receivers, transmitters, and noise*

$$v_n = \sqrt{4kTBR} \qquad P_n = kTB$$

$$k = 1.38\times10^{-23}\ J/K \qquad i_n = \sqrt{2qI_{DC}B}$$

$$q = 1.6\times10^{-19}\ \text{C} \qquad S/N = \frac{Ps}{Pn}$$

$$NR = NR_1 + \frac{NR_2 - 1}{A_{P1}} + \frac{NR_3 - 1}{A_{P1}\cdot A_{P2}} + \frac{NR_4 - 1}{A_{P1}\cdot A_{P2}\cdot A_{P3}} + \cdots \qquad T_N = 290\,(NR - 1)$$

$$R = MN + A \qquad NR = \frac{S/N_{INPUT}}{S/N_{OUTPUT}}$$

$$MDS = -174dBm + 10\log(B) + NF$$

Datakommunikasie / *Data communication*

$$V_{out} = \frac{V_m \ln\left(1 + \frac{\mu V_{in}}{V_m}\right)}{\ln(1+\mu)} \qquad V_{out} = \frac{1 + \ln\left(\frac{AV_{in}}{V_{in}}\right)}{1 + \ln(A)}$$

$$C = 2B\log_2(N) \qquad C = B\log_2\left(1 + \frac{S}{N}\right)$$

$$\frac{E_b}{N_0} = \left(\frac{C}{N}\right)\left(\frac{B}{f_B}\right) \qquad v_n = \frac{q}{\sqrt{12}}$$

RF transmissie / *RF transmission*

$$\frac{P_R}{P_T} = \frac{G_R G_T \lambda^2}{(4\pi)^2 d^2 L} \qquad PL(d) = PL(d_0) + 10n\log\left(\frac{d}{d_0}\right)$$

$$c = f\lambda$$

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