NORTH-WEST UNIVERSITY
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POTCHEFSTROOMKAMPUS

Benodigdhede vir hierdie vraestel/Requirements for this paper:			
Multikeusekaarte/ Multi-choice cards:		Nie-programmeerbare sakrekenaar/ Non-programmable calculator:	X
Grafiekpapier/ Graph paper:		Draagbare Rekenaar/ Laptop:	

Oopboek-eksamen/ Open book examination?	NEE/ NO

EKSAMEN/TOETS EXAMINATION/TEST:	EERSTE GELEENTHEID	KWALIFIKASIE/ QUALIFICATION:	B ING
MODULEKODE/ MODULE CODE:	EERI 423	TYDSDUUR/ DURATION:	3 uur/hour
MODULEBESKRYWING/ MODULE DESCRIPTION:	TELEKOMMUNIKASIE STELSELS TELECOMMUNICATION SYSTEMS	MAKS/ MAX:	105
EKSAMINATOR(E)/E EXAMINER(S):	MNR H MARAIS	DATUM/ DATE:	05/11/2010
		TYD/TIME:	09:00
MODERATOR:	MNR P OBERHOLSTER		

TOTAAL/TOTAL: 105

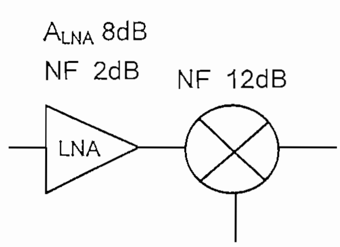
Question 1 [12]

1.1 Verklaar die volgende tipes kommunikasie: / *Describe the following types of communication*:

a) Simpleks / *Simplex* (1)
b) Half dupleks / *Half duplex* (1)
c) Vol dupleks / *Full duplex* (1)

1.2 Indien die seindrywing 1W is en die ruisdrywing 83mW is, wat is die sein-tot-ruis verhouding in dB? / *If the signal power is 1W and the noise power is 83mW, what is the signal to noise ratio in dB?* (2)

1.3 Bereken die ruistal vir die onderstaande ontvangerketting en druk dit uit in desibel. / *Calculate the total noise figure for the receiver chain shown in the figure below and express it in decibels.* (7)



Question 2 [26]

2.1 Be antwoord die volgende vrae: / *Answer the following:*

a) Hoe is modulasie-indeks gedefinieer? / *How is modulation index defined?* (2)
b) Vir watter tipes ruis is QAM sensitief? / *To which types of noise are QAM sensitive?* (2)

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2.2 'n AM sein bestaan uit 'n draer van 27MHz wat gemoduleer word met n sinusoidale sein van 8kHz. Dit het 'n maksimum omhulsel van 19V en 'n minimum van 10V. / *An AM signal comprises a carrier of 27MHz that is modulated by a sinusoidal input at 8kHz. The envelope of the modulated signal has a peak of 19V and a minumum of 10V*

a) Wat is die piekwaarde van die ongemoduleerde draer? / *What is the peak value of the unmodulated carrier?* (2)
b) Bereken die modulasie-indeks. / *Calculate the modulation index.* (2)
c) Is die sein oor- of ondergemoduleer? Motiveer jou antwoord. / *Is the signal over or under modulated? Motivate your answer.* (2)

2.3 'n FM versender funksioneer met 'n draerfrekwensie van 433MHz data word met 'n modulasiefrekwensie van 112.5kHz gemoduleer teen 'n modulasie indeks van 0.7. Die totale uitsetdrywing van die versender is $4W_{RMS}$ in 'n 50Ω las. / *An FM transmitter is operating at a carrier frequency of 433MHz with a modulation index of 0.7 with a modulation frequency of 112.5kHz. The total power output of the transmitter is* $4W_{RMS}$ *into a 50Ω load.*

a) Verskaf die frekwensie-afwyking. / *Provide the frequency deviation.* (2)
b) Bereken die piekspanning van die draer. / *Calculate the peak voltage of the carrier.* (2)
c) Skets die spektrum van die sein insluitende die sybande wat meer as 1% van die seinspanning bevat / *Sketch the spectrum of the signal including the sidebands with more than 1% of the signal voltage;* (6)
d) Wat is die bandwydte van die stelsel (vir alle praktiese doeleindes)? / *What is the bandwidth of the system (for all practical reasons)?* (2)
e) Bereken die bandwydte deur van Carson se reël gebruik te maak / *Calculate the bandwidth using Carson's rule;* (2)
f) Vergelyk die antwoorde in (d) en (e) en maak 'n gevolgtrekking / *Compare the answers in (d) and (e) above and draw a conclusion.* (2)

Question 3 [10]

3.1 Noem twee tipes datakompressie en verskaf ook 'n tipiese voorbeeld van elk. / *Descibe two types of data compression and also provide a typical application for each.* (4)

3.2 Veronderstel dat 'n saamgestelde videosein met 'n bandwydte van GS tot 4MHz versyfer moet word deur 'n 10bis ADO teen 13Mbps. Bereken die: / *Suppose that a composite video signal with a bandwith from DC to 4MHz must be sampled by a 10bit ADC at 13Msps. Calculate the:*

a) aantal kwantiseringsvlakke wat deur die ADO verskaf word / *number of quantisation levels provided by the ADC;* (1)
b) bistempo wat deur die ADO produseer word / *bitrate produced by the ADC;* (2)
c) sein-tot-ruis verhouding / *signal to noise ratio;* (2)
d) Watter tipe ruis bepaal die antwoord in (c) / *What type of noise determines the answer in (c)?* (1)

Question 4 **[10]**

4.1 'n Radiokanaal het 'n maksimum bandwydte van 50kHz en 'n sein-tot-ruis verhouding van 17dB. Beantwoord die volgende: / *A radio channel has a maximum bandwidth of 50kHz and a signal-to-noise ratio of 17dB. Answer the following questions:*

a) Wat is die teoretiese maksimum informasie kapasiteit van die kanaal (aldus Shannon)? / *What is the theoretical maximum information capacity of the channel (according to Shannon)?* (2)

b) Wat is die teoretiese informasiekapasiteit indien 4-PSK as die modulasieskema gebruik word? / *What is the theoretical information capacity limit if 4-PSK is used as the modulation scheme?* (2)

4.2 'n DSSS stelsel maak gebruik van FSK en gebruik 'n *"chipping rate"* van 40:1. Na die sein gesprei is, is die sien tot ruis verhouding -8dB. Indien die data teen 57600bps versend word bereken die volgende: / *A DSSS system makes use of FSK and a chipping rate of 40:1. After spreading the signal-to-noise ration of the is -8dB. If the data is transmitted at 57600bps calculate:*

a) Die *"chipping rate"* van die stelsel / *The chipping rate of the system;* (1)

b) Bandwydte van die sein nadag dit gesprei is / *Bandwidth used after spreading;* (2)

c) Sein-tot-ruis verhouding van die herwinde sein / *Signal-to-noise ratio of the de-spreaded signal.* (3)

Question 5 **[17]**

5.1 Beantwoord asseblief die volgende vrae: / *Please answer the following questions:* (7)

a) 'n 75W isotropiese bron word aan 'n antenna met 'n wins van 12dBi gekoppel. Bereken die EIRP van die bron-antenna kombinasie in dB / *An isotropic source of 75W is connected to an antenna with a gain of 12dBi. Calculate the EIRP of the source-antenna combination in dB;* (2)

b) Wat is die effektiewe area van die antenne in (a) indien die gebruiks frekwensie 200MHz is / *What is the effective area of the antenna in (a) if the operating frequency is 200MHz?* (3)

c) Wat sal die effek van n direksionele antenne wees op die: / *What would the effect of a directional antenna be on:* (2)

1. Opvangsafstand / *Reception distance*
2. Opvangsarea / *Reception area*

5.2 'n 2.4GHz WiFi roeteerder het 'n uitsetdrywing van 100mW. Dit word verbind aan 'n 20dBi direksionele antenne deur 'n 10m kabel. Die tegniese data van die kabel toon 'n verlieswaarde van 54dB/100m. Elk van die koppelstukke het ook 'n verlies van 0.3dB tot gevolg. / *A 2.4GHz WiFi router has an output power of 100mW. It is connected to a 20dBi directional antenna by a cable of 10m. The technical data of the cable shows a loss of 54dB/100m. Each of the cable connectors have an associated loss of 0.3dB* (10)

a) Hoeveel drywing bereik die antenne / *How much power reaches the antenna*? (3)

b) Bereken die EIRP / *Calculate the EIRP.* (2)

c) Aanvaar dat 'n ontvangsantenne met 'n wins van 6dBi gebruik word en dat die ontvangersensitiwiteit -100dBm is (soos gemeet by die antenna). Wat is die maksimum afstand waaroor kommunikasie kan plaasvind? (Maak gebruik van die vrye ruimte model) / *Assuming that a reception antenna with a gain of 6dBi is used and that the receiver sensitivity is -100dBm (as measured at the reception antenna) what is the maximum communication distance? Make use of free space propagation.* (5)

Question 6 **[18]**

6.1 Teken 'n blokdiagram van 'n tipiese heterodene versender (benoem alle blokke duidelik). / *Draw a block diagram of a typical heterodyne transmitter (clearly label all blocks).* (10)

6.2 Definieer die volgende versender spesifikasies: / *Define the following transmitter specifications:* (2)

a) Spektrale suiwerheid / *Spectral purity;*
b) Drywingsuitset. / *Power output.*

6.3 Twee seine van 20MHz en 860MHz onderskeidelik word by 'n menger ingevoer. Watter frekwensies is by die menger uitset teenwoordig? / *Two signals of 20MHz and 860MHz respectively are fed into a mixer. Which frequencies are produced at the output?* (2)

6.4 'n FM ontvanger met 'n IF van 20MHz word ingestem by 'n frekwensie van 590MHz. Aanvaar dat "high-side" invoer gebruik word en bereken die: / *A FM receiver with a IF of 20Mhz is tuned to a frequency of 590MHz. Assuming that high-side injection is used calculate the:* (4)

a) Lokale ossilator frekwensie / *Local oscillator frequency;*
b) Beeldfrekwensie. / *Image frequency.*

Question 7 **[12]**

7.1 'n sellulêre stelsel maak gebruik van n 12-sel herhalingspatroon en het 120 selle. Daar is 'n totaal van 24000 intekenaars wat elk die diens vir 'n gemiddeld van 28 minute per dag gebruik. Daarvan is 10 minute in die piek gebruiksuur. Bereken die volgende: / *A cellular system using a 12-Cell repeating pattern has 120 cells and 24000 subscribers. Assuming that each subscriber uses the services for 28 minutes per day and that 10 minutes thereof are during peak hours calculate the following:*

a) Gemiddelde en piek verkeer vir die totale stelsel / *Average and peak traffic for the whole system* (2)
b) Gemiddelde en piek verkeer vir 'n enkele sel (aanvaar n eweredige verspeiding van intekenaars) / *Average and peak traffic for a single cell (assume an equal distribution of subscribers)* (2)
c) Waarskynlikheid dat n oproep geblokkeer sal word gedurende normale gebruik (uitgedruk per sel) / *Call blocking probability during off-peak hours (expressed per cell)* (1)
d) Waarskynlikheid dat 'n oproep geblokkeer sal word gedurende die piek uur (uitgedruk per sel) / *Call blocking probability during the peak hour (expressed per cell)* (1)

Number of Cells	1%	2%	5%
19	11.2	12.3	14.3
33	22.9	24.6	27.7
55	42.4	44.9	49.5
97	81.2	85.1	92.2

7.2 Skets n blokdiagram van 'n tipiese sellulêre stelsel. Toon slegs 'n enkele basisstasie aan! / *Draw a block diagram of a typical cellular system. Only a single base station needs to be shown!* (8)

$$e(t) = E_c \sin(\omega_c t + \theta)$$

$$P_N = kTB$$

$$T(K) = T(°C) + 273$$

$$NF = \frac{(S/N)_i}{(S/N)_o}$$

$$NF_T = NF_1 + \frac{NF_2 - 1}{A_1} + \frac{NF_3 - 1}{A_1 A_2} + \cdots$$

$$T_{eq} = 290(NF - 1)$$

$$f(t) = \frac{A_o}{2} + A_1 \cos \omega t + B_1 \sin \omega t + A_2 \cos 2\omega t + B_2 \sin 2\omega t + A_3 \cos 3\omega t + B_3 \sin 3\omega t + \cdots$$

$$N_0 = kT$$

$$v = f\lambda$$

$$c = f\lambda$$

$$I = ktB$$

$$P_r = P_t + G_t + G_r - L_{fs}$$

$$L_{fs} = 32.44 + 20 \log d + 20 \log f$$

$$d = \sqrt{17h_t} + \sqrt{17h_r}$$

$$L_p = 68.75 + 26.16 \log f - 13.82 \log h + (44.9 - 6.55 \log h) \log d$$

$$T = \frac{c}{2fv}$$

$$N = \frac{A}{3.464r^2}$$

$$f_0 = Nf_{ref}$$

$$\eta = \frac{P_o}{P_s}$$

$$f_{IF} = f_{LO} - f_{SIG}$$

$$f_{LO} = f_{SIG} + f_{IF}$$

$$f_{IF} = f_{SIG} - f_{LO}$$

$$f_{LO} = f_{SIG} - f_{IF}$$

$$f_s = \left(\frac{m}{n}\right) f_{LO} \pm \frac{f_{IF}}{n}$$

$$f_a = f_s - f_b$$

$$v(t) = \frac{E_b}{T} \sin \omega_b t + \frac{E_b \sin \pi\tau/T}{\pi\tau} \sin(\omega_s + \omega_b)t - \frac{E_b \sin \pi\tau/T}{\pi\tau} \sin(\omega_s - \omega_b)t$$

$$N = 2^{m}$$

$$DR = 1.76 + 6.02m \text{ dB}$$

$$D = f_s m$$

$$v_o = \frac{V_o \ln(1 + \mu v_i/V_i)}{\ln(1 + \mu)}$$

$$I = ktB$$

$$C = 2B \log_2 M$$

$$C = B \log_2(1 + S/N)$$

$$C = S \log_2 M$$

$$f_m - f_s = 0.5 f_b$$

$$G_p = \frac{B_{RF}}{B_{BB}}$$

$$G_p \text{ (dB)} = (S/N)_i \text{ (dB)} - (S/N)_o \text{ (dB)}$$

$$v_p = \frac{c}{\sqrt{\epsilon_r}}$$

$$P_D = \frac{EIRP}{4\pi r^2}$$

$$\mathcal{E} = \frac{\sqrt{30EIRP}}{r}$$

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$$d = \sqrt{17h_t} + \sqrt{17h_r}$$

$$L_{fs} = 32.44 + 20 \log d + 20 \log f$$

$$T = NP$$

$$m_T = \sqrt{m_1^2 + m_2^2 + \cdots}$$

$$E_{max} = E_c(1 + m)$$

$$E_{min} = E_c(1 - m)$$

$$m = \frac{E_{max} - E_{min}}{E_{max} + E_{min}}$$

$$v(t) = E_c \sin \omega_c t + \frac{mE_c}{2} \cos(\omega_c - \omega_m)t - \frac{mE_c}{2} \cos(\omega_c + \omega_m)t$$

$$f_{usb} = f_c + f_m$$

$$f_{lsb} = f_c - f_m$$

$$E_{lsb} = E_{usb} = \frac{mE_c}{2}$$

$$B = 2f_m$$

$$P_{lsb} = P_{usb} = \frac{m^2}{4} P_c$$

$$P_{sb} = \frac{m^2}{2} P_c$$

$$P_t = P_c\left(1 + \frac{m^2}{2}\right)$$

$$m = 2\sqrt{\frac{P_{lsb}}{P_c}}$$

$$m_f = \frac{\delta}{f_m}$$

$$\begin{aligned} v(t) &= A \sin (\omega_c t + m_f \sin \omega_m t) \\ &= A \{J_0(m_f) \sin \omega_c t - J_1(m_f)[\sin (\omega_c - \omega_m)t - \sin (\omega_c + \omega_m)t] \\ &\quad + J_2(m_f) [\sin (\omega_c - 2\omega_m)t + \sin (\omega_c + 2\omega_m)t] \\ &\quad - J_3(m_f)[\sin (\omega_c - 3\omega_m)t + \sin (\omega_c + 3 \omega_m)t] \\ &\quad + \cdots\} \end{aligned}$$

$$B = 2[\delta_{(max)} + f_{m(max)}]$$

$$\phi_N = \frac{E_N}{E_S}$$

$$v(t) = (E_c + E_m \sin \omega_m t) \sin \omega_c t$$

$$m = E_m/E_c$$

$$v(t) = E_c(1 + m \sin \omega_m t) \sin \omega_c t$$

TABLE 2.1 Bessel Functions

m	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}	J_{11}	J_{12}	J_{13}	J_{14}	J_{15}	J_{16}	J_{17}	J_{18}	J_{19}	J_{20}
0	1.00																				
0.25	0.98	0.12																			
0.5	0.94	0.24	0.03																		
0.75	0.86	0.35	0.07	0.01																	
1	0.77	0.44	0.11	0.02																	
1.25	0.65	0.51	0.17	0.04	0.01																
1.5	0.51	0.56	0.23	0.06	0.01																
1.75	0.37	0.58	0.29	0.09	0.02																
2	0.22	0.58	0.35	0.13	0.03	0.01															
2.25	0.08	0.55	0.40	0.17	0.05	0.01															
2.4	0.00	0.52	0.43	0.20	0.06	0.02															
2.5	−0.05	0.50	0.45	0.22	0.07	0.02															
2.75	−0.16	0.43	0.47	0.26	0.10	0.03	0.01														
3	−0.26	0.34	0.49	0.31	0.13	0.04	0.01														
3.5	−0.38	0.14	0.46	0.39	0.20	0.08	0.03	0.01													
4	−0.40	−0.07	0.36	0.43	0.28	0.13	0.05	0.01													
4.5	−0.32	−0.23	0.22	0.42	0.35	0.20	0.08	0.03	0.01												
5	−0.18	−0.33	0.05	0.36	0.39	0.26	0.13	0.05	0.02	0.01											
5.5	0.00	−0.34	−0.12	0.26	0.40	0.32	0.19	0.09	0.03	0.01											
6	0.15	−0.28	−0.24	0.11	0.36	0.36	0.25	0.13	0.06	0.02	0.01										
6.5	0.26	−0.15	−0.31	−0.03	0.28	0.37	0.30	0.18	0.09	0.04	0.01										
7	0.30	−0.01	−0.30	−0.17	0.16	0.35	0.34	0.23	0.13	0.06	0.02	0.01									
7.5	0.27	0.14	−0.23	−0.26	0.02	0.28	0.35	0.28	0.17	0.09	0.04	0.01	0.01								
8	0.17	0.24	−0.11	−0.29	−0.11	0.19	0.34	0.32	0.22	0.13	0.06	0.03	0.01								
8.5	0.04	0.27	0.02	−0.26	−0.21	0.07	0.29	0.34	0.27	0.17	0.09	0.04	0.02	0.01							
8.65	0.00	0.27	0.06	−0.24	−0.23	0.03	0.27	0.34	0.28	0.18	0.10	0.05	0.02	0.01							
9	−0.09	0.25	0.14	−0.18	−0.27	−0.06	0.20	0.33	0.30	0.21	0.13	0.06	0.03	0.01							
10	−0.25	0.04	0.26	0.06	−0.22	−0.23	−0.01	0.22	0.32	0.29	0.21	0.12	0.06	0.03	0.01						
11	−0.17	−0.18	0.14	0.23	−0.01	−0.24	−0.20	0.02	0.23	0.31	0.28	0.20	0.12	0.06	0.03	0.01	0.01				
12	0.05	−0.22	−0.08	0.20	0.18	−0.07	−0.24	−0.17	0.04	0.23	0.30	0.27	0.20	0.12	0.07	0.03	0.01	0.10			
13	0.21	−0.07	−0.22	0.00	0.22	0.13	−0.12	−0.24	−0.14	0.07	0.23	0.29	0.26	0.19	0.12	0.07	0.03	0.01	0.01		
14	0.17	0.13	−0.15	−0.18	0.08	−0.15	−0.23	−0.11	0.08	0.24	0.29	0.25	0.19	0.12	0.07	0.03	0.02	0.01			
15	−0.01	0.20	0.04	−0.19	−0.12	0.13	0.21	0.03	−0.17	−0.22	−0.09	0.10	0.24	0.28	0.25	0.18	0.12	0.07	0.03	0.02	0.01
16	−0.17	0.09	0.19	−0.04	−0.20	−0.06	0.17	0.18	−0.01	−0.19	−0.21	−0.07	0.11	0.24	0.27	0.24	0.18	0.11	0.07	0.03	0.02
17	−0.17	−0.10	0.16	0.14	−0.11	−0.19	0.00	0.19	0.15	−0.04	−0.20	−0.19	−0.05	0.12	0.24	0.27	0.23	0.17	0.11	0.07	0.04