Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	INDUSTRIAL COMMUNICATION SYSTEMS
COURSE CODE	:	BND 32603
PROGRAMME CODE	:	BND
EXAMINATION DATE	:	JULY / AUGUST 2023
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER **ALL** QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA **OPEN BOOK**

THIS QUESTION PAPER CONSISTS OF **SEVEN** (7) PAGES

Q1 (a) A network's logical topology is how the hosts communicate across the medium. State at least **THREE (3)** basic topologies together with their respective topology diagrams.

(6 marks)

(b) Briefly explain the basic function of every Open System Interconnection layer.

(7 marks)

(c) A non-periodic composite signal contains frequencies from 10 to 30 kHz. The peak amplitude is 10 V for the lowest and the highest signals and is 30 V for the 20 kHz signal. Assuming that the amplitudes change gradually from the minimum to the maximum.

(i) Draw the frequency spectrum.

(3 marks)

(ii) Calculate the bandwidth of the signal.

(1 mark)

(iii) According to the channel bandwidth of the signal at (ii), compute the minimum SNR in dB and linear.

(3 marks)

Q2 (a) Ethernet is the most widely used local area network protocol. The Ethernet 802.3 MAC Frame contains seven fields. Sketch and briefly explain the function of these fields with the details of their respective length.

(10 marks)

(b) An organization is granted block 192.200.0.0/20. The administrator wants to create 500 fixed-length subnets.

(i) Find the subnet mask address.

(3 marks)

(ii) Find the number of addresses in each subnet.

(2 marks)

(iii) Find the first and last address in subnet 1.

(2 marks)

(iv) Find the first and last addresses in subnet 500.

(3 marks)

Q3 (a) The Highway Addressable Remote Transducer (HART) and FOUNDATION Fieldbus are an industrial protocol standard that has been used for many years. Briefly discuss main features of these **TWO (2)** protocols and suggest the most suitable protocol to be implemented with the digital field instrument and real-time closed loop control system. Provide justification of your choice.

(5 marks)

(b) The basic communication of the HART protocol is the 4–20 mA current system. This analog system is used by the sensor to transmit an analog value to the PLC or HART card in a PC. In a 4–20 mA system, the sensor outputs a current value somewhere between 4 and 20 mA that represents the analog value of the sensor. The pressure transmitter with a range of 1 bar to 100 bar is used to measure boiler tank pressure.

(i) Calculate the measured transmitter current value for 45 bars.

(3 marks)

(ii) Calculate the pressure value for transmitter current of 10 mA

(3 marks)

(c) Foundation Fieldbus is an all-digital, serial, two-way communications system that serves as the base-level network in a plant or factory automation environment. It is an open architecture, developed and administered by the Fieldbus Foundation.

(i) **Figure Q3 (c)(i)**, represents Manchester encoding, which is how the actual data is encoded in the H1 Foundation Fieldbus network. Draw the shape of the Manchester encoding data for input data pattern 1011011.

(3 marks)

(ii) The FOUNDATION Fieldbus H1 Network uses twisted-pair wires to minimize externally induced electromagnetic noise in the wires. State the speed of H1 communication and calculate the maximum permissible trunk length with 6 spurs of 50 meters each if the maximum cable length is 1900 m (Type A).

(2 marks)

(iii) Evaluate the worst-case scenarios for one segment (10 transmitters and 2 control loops) to identify whether the Foundation Fieldbus power supply provides sufficient voltage based on the total devices available in the pilot plant as listed in the **Table Q3 (c)(iii)**.

Hint:

$$V_D = V_P - \left[\sum \quad I_D + I_{HH} + (I_{SC} - I_{Dmin}) + I_C + I_H \times \left(R \times (L_{tmax+}L_{spurs+})\right)\right]$$

(4 marks)

Q4 (a) In telecommunication, free-space path loss (FSPL) is the loss in signal strength of an electromagnetic wave that would result from a line-of-sight path through free space (usually air), with no obstacles nearby to cause reflection or diffraction. Derive the free-space path loss formula in decibels.

(5 marks)

(b) A temperature transmitter transmitted a 15 mW of power to a Distributed Control System (DCS) receiver with a distance of 75 m. The carrier frequency is 2.4 GHz. The antenna gain of the transmitter is 30 (in linear) and the gain of the receiver antenna is 2 dB. Environmental loss of 3 dB should also take into consideration.

(i) Express the transmit power in units of dBW and dBm.

(2 marks)

(ii) Calculate the effective isotropic radiated power in milliwatt (mW).

(2 marks)

(iii) Calculate the free space path loss.

(2 marks)

(iv) Compute the received power in watt (W).

(3 marks)

(v) Compute the Carrier-to-Noise Ratio (CNR). The equivalent noise temperature of the receiver T is 25°C and the bandwidth B is 100 MHz.

(3 marks)

(vi) If the Carrier-to-noise ratio (CNR) of the field communication system require at least 60 dB for the field communication system, investigate how much transmit power (in Watt) should be increased in order to achieve such requirement.

(3 marks)

Q5 (a) The performance of radio link is measured as the percentage of time the link is available or outage over a given time period. Calculate the outage time in a year for a link availability of 99.95 %.

(2 marks)

(b) A general design rule for microwave links is 50 % clearance of the first Fresnel zone. For a 1 km link at 2.5 GHz, Determine the maximum first Fresnel zone radius? Calculate the clearance height above the obstruction to the Line of Sight (LOS) path.

(3 marks)

(c) A geostationary satellite carries a Ku-band (12 GHz) transponder which transmit effective isotropic radiated power (Eirp) of 20W with an antenna gain of 30 dB. An earth station with the unity antenna gain is looking at the satellite transponder with the elevation angle of 45°. The vertical distance (90°) of earth station to satellite transponder is assume 36,000 km.

(i) Identify transmitted power from satellite transponder.

(1 marks)

(ii) Compute free space path loss of satellite link to earth station.

(3 marks)

(iii) Analyze power received at the earth station with a clear sky condition.

(4 marks)

(iv) Suggest appropriate propagation impairment mitigation technique to improve satellite link quality of services (QoS) under heavy rain conditions. Justified your answer accordingly.

(2 marks)

(d) Briefly discuss the SCADA system component with the aid of diagram.

(5 marks)

- END OF QUESTIONS –

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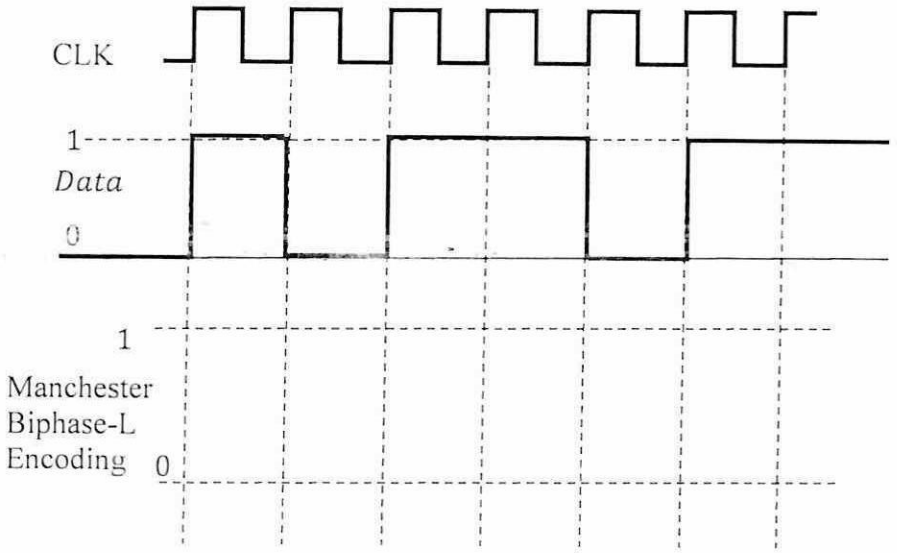

Figure Q3 (c)(i)

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Table Q3 (c)(iii)

Device characteristics summary

Instrument	Manufacturer	Model	Current per devices I_d (mA)	Number of devices
Pressure Transmitter	Emerson Electric	Rosemount 3051	20	5
Temperature Transmitter	ABB	TTF 300	10	5
Level Transmitter	Yokogawa	EJX 210A	15	4
Control loops (valve)	Siemens	DV2T	24	2

Power supply voltage Vp = 24V DC

Current consumption budget for handheld meter I_{HH} = 5 mA

Current load for short circuit protection I_{SC} = 48 mA

Current load of Field Device I_{Dmin} = 10 mA

Current load of device coupler I_C = 5 mA

Current load of host I_H = 12 mA

Resistance of cable R = 30 Ω/km (return) (Type A)

Current load of control loop = 25 mA

Maximum possible length of trunk L_{tmax} = Total cable budget –total spurs length

Length of longest spur L_{spurL} =120 m