



Second Semester Examination
2022/2023 Academic Session

July/August 2023

EEK470 – ELECTRIC POWER DISTRIBUTION SYSTEM

Duration: 3 hours

Please ensure that this examination paper consists of SEVEN (7) pages printed material including appendix before you begin the examination.

Instructions: This question paper consists of **TWO (2)** questions. Answer **ALL** questions. All questions carry the same marks.

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1. Answer the following questions on load distribution network.
- (a) A distribution transformer supplies power to three different users i.e. street lighting, commercial and industrial loads. Table 1 shows the daily load data of these users. Determine the following:
- (i) The contribution factor for each of the load classes. (10 marks)
 - (ii) The load factor for each of the load classes. (10 marks)
 - (iii) The diversity factor of the load group. (10 marks)
 - (iv) The load diversity of the load group. (10 marks)

Table 1

Time	Load (kW)		
	Street Lighting	Commercial	Industrial
12am – 4am	150	100	200
4am – 6am	150	200	400
6am – 9am	0	400	500
9am – 12pm	0	1000	2000
12pm – 5pm	0	1200	2500
5pm – 7pm	75	400	500
7pm – 8pm	150	200	400
8pm – 12am	150	100	200

- (b) Discuss the criteria that should be considered when choosing a suitable location for a distribution substation. (10 marks)

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- (c) A primary feeder from a distribution substation supplies power to a small town. The total annual energy consumed by the town is about 115 million units. It was also recorded that the feeder experienced an annual peak load of 25 MW. Determine the annual load factor of the feeder.

(10 marks)

- (d) An octagon-shaped residential area is served by a substation located at the center. The primary distribution system consists of 8 primary main feeders with each feeder serving a triangular service area as shown in Figure 1. The substation provides 3-phase power with $V_{L-L} = 11$ kV and a lagging load power factor of 0.90. The main feeders are designed to be thermally limited with a maximum current rating of 200 A and a K constant of 0.001 %VD/(kVA-km). Assuming that the service area has a uniform load density of 1350 kVA/km², calculate the followings:

- (i) The size of the area served by one primary main feeder.

(10 marks)

- (ii) The length of the primary main feeder.

(10 marks)

- (iii) The power rating of the substation.

(10 marks)

- (iv) The percentage voltage drop at the end of the main feeder.

(10 marks)

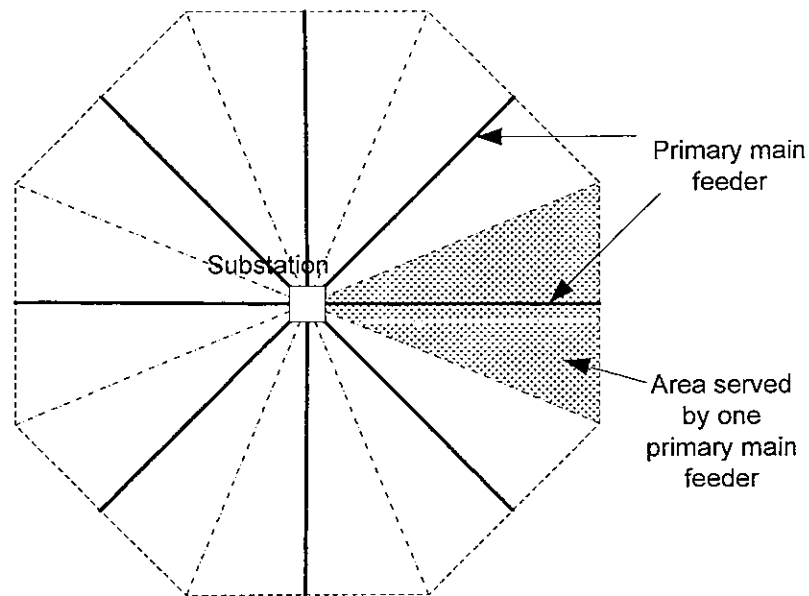


Figure 1

2. Figure 2.1 shows a typical connection of relays and protection equipment. As a protection system engineer, you are required to perform the settings of the relays to ensure proper coordination among the relays and subsequently the discrimination of fault. Assume that the operating time of relay F1 is 0.02 s with TMS of 0.1 s and of relay F2 is 0.05 s with TMS of 0.25 s. The fuse pre-arcing time is 0.01 s. Required relay-to-relay grading margin is 0.3 s. The utility requires that relay 5 be graded using a standard inverse characteristic. Useful equations.

$$\text{Extreme inverse (EI) characteristic} = TMS \times \frac{80}{I_r^2 - 1}$$

$$\text{Standard inverse (SI) characteristic} = TMS \times \frac{0.14}{I_r^{0.02} - 1}$$

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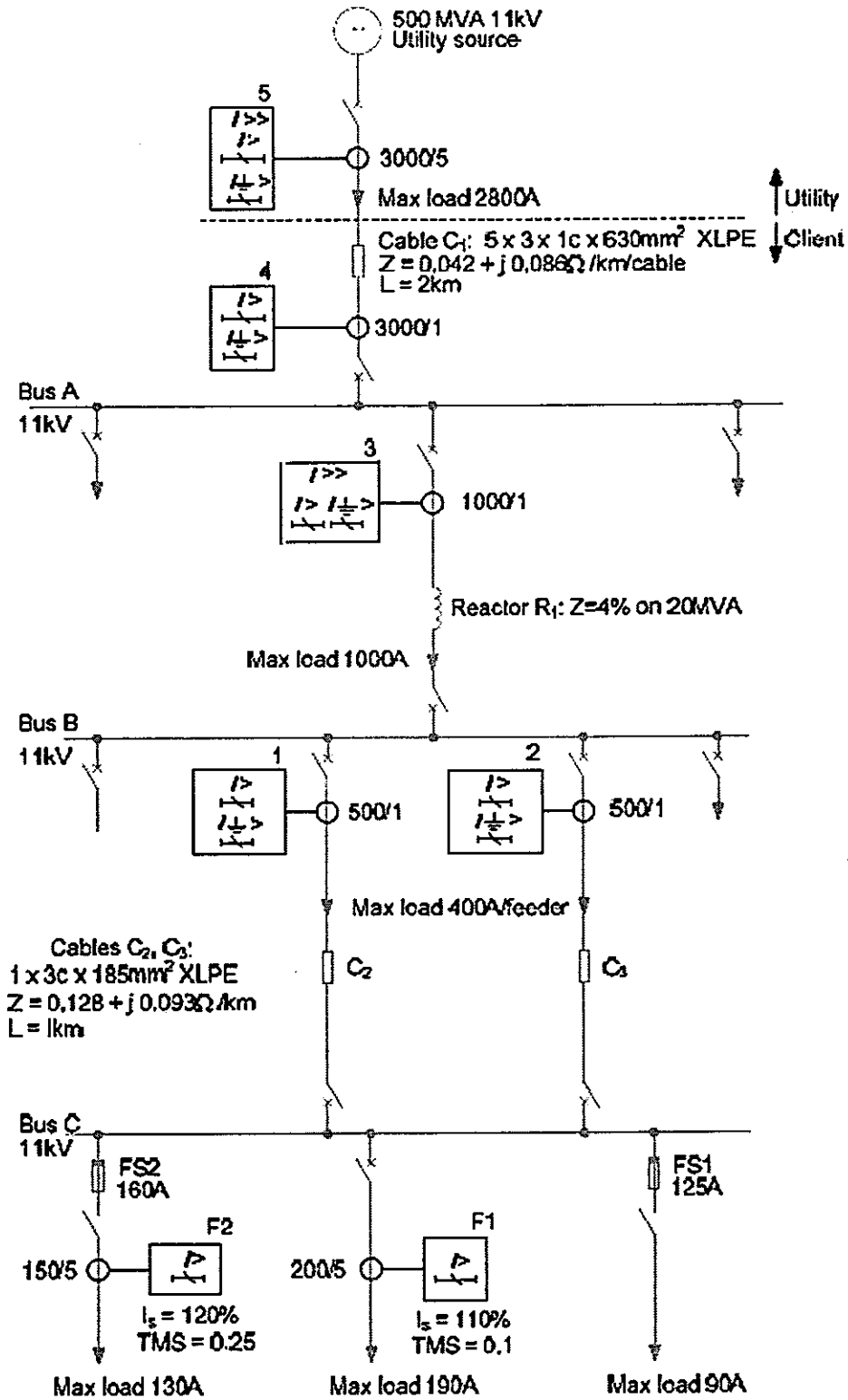


Figure 2

As a protection system engineer, you are also aware that fault current at each bus is needed before coordination can be performed. Hence:

- (a) Determine the maximum fault current at buses C, B and A that will be seen by the relays. Use base power of 500 MVA. Hint: Use Thevenin theorem.

(40 marks)

- (b) Determine the setting of TMS and current setting of the relays 1 to 4. Assume that the TMS of relay 1 and 2 is limited to 1. In order to ensure grading with downstream fuses, EI characteristic is used for these two relays. Also, relay 3 does not operate for the maximum through-fault current seen by it and a setting of 130% of this value is satisfactory.

(60 marks)

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APPENDIX A

QUESTION NUMBER	CO	PO
1	3	3
2	2	3