

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2082 Chaitra

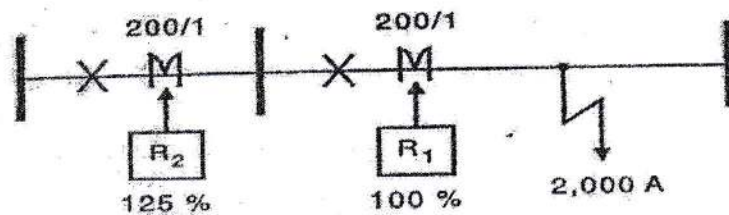
Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Switchgear and Protection (EE 651)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) Discuss why backup protection is necessary in a power system and explain the overlapping of protective zones with neat sketch. [4]
- b) A current transformer is connected in a 400 V system and has a single turn on its primary and 180 turns on its secondary. An ammeter with 0.15Ω internal resistance is connected to the CT. The ammeter is required to give a full-scale deflection when the primary current is 900 A. Calculate, [4]
 - i) The maximum secondary current
 - ii) Secondary voltage at CT terminals when ammeter is removed
- c) Explain the cut-off characteristics of a fuse. [4]
2. a) List down the different applications of contactor. With the help of necessary schematic circuit explain how star-delta starting of motor can be achieved with the help of contactors. [6]
- b) Calculate the inductance and kVA rating of Peterson coil of a 230 kV, 3-phase, 50 Hz, 200 km overhead transmission system having capacitance to earth of $0.01 \mu\text{F}/\text{km}$ per phase. [5]
- c) With the help of neat sketch, explain the types of isolators and state the major differences between isolator and circuit breaker. [5]
3. a) A 3 phase 50 Hz alternator having an inductance of 1.5 mH per phase is connected to a bus bar through a circuit breaker. The neutral of the alternator is grounded. The capacitance to earth of the circuit between the alternator and the circuit breaker is $0.0029 \mu\text{F}$ per phase. Due to a fault on the bus bar, the circuit breaker opens when the rms value of the fault current is 7800 A. Determine the following: [2+2+2+2]
 - i) Active recovery voltage
 - ii) Frequency of oscillation
 - iii) Time to attain max RRRV
 - iv) Max RRRV
- b) Discuss any three types of circuit breaker suitable for cold and snowy conditions, explaining the reasons for your selection. Compare their performance in terms of arc-quenching mechanism, maintenance requirements, and operating voltage range. [8]
4. a) A 11 kV, 100 MVA generator is grounded through a resistance of 6Ω . The CTs have a ratio of 1000:5. The relay is set to operate when there is an out of balance current of 1A. What percentage of generator winding will be protected by percentage differential scheme of protection? [6]

- b) In the given figure below, the fault current is 2000 A and the CTs are of ratio = 200:1. The plug setting of Relay R_1 is 100% and the plug setting of Relay R_2 is 125%. The time grading scheme has a discriminative time margin of 0.5s between the relays and the time multiplier setting (TMS) of R_1 is 0.2. [8]



Determine the time of operation of the two relays assuming that both relays have the characteristics as shown in the following table. Also determine the TMS of R_2 .

PSM	2	3.6	5	8	10	15	20
Time for unity TSM	10	6	3.9	3.15	2.8	2.2	2.1

- c) What is an impedance relay? Explain its operating principle and characteristic along with torque equation. [6]
5. a) Discuss the essential components of static relay with block diagram. [8]
- b) With the help of neat block diagram, explain the function of directional static overcurrent relay. [8]

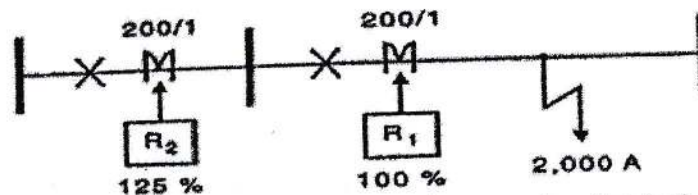
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1. a) Define the term selectivity and sensitivity in power system protection. How does selectivity and sensitivity ensure proper fault isolation and continuity of service? [6]
- b) A current transformer whose current ratio is 300/5 ampere and the Instrument Security Factor is 1.5 is installed in a feeder. If the primary current becomes 4500 ampere due to a fault, then how much will the secondary current be? [4]
- c) Explain the advantages and disadvantages of fuses compared to MCBs in terms of operation, maintenance, response time, and their suitability for various applications. [6]
2. a) What are the basic difference between isolator and circuit breaker? Explain why we use isolator and circuit breaker simultaneously. [6]
- b) A 60 km long 66 kV, 50 Hz 3 phase overhead line has line to earth capacitance of each phase equal to 0.02 $\mu\text{F}/\text{km}$. Determine the inductance and kVA rating of the arc suppression coil. [4]
- c) Define neutral earthing. Briefly discuss different types of neutral earthing. [4]
3. a) In a 132 kV system, the reactance and capacitance up to the location of circuit breaker is 6 Ω and 0.02 μF , respectively. A resistance of 500 Ω is connected across the contacts of the circuit breaker. Determine the following: (a) Natural frequency of oscillation, (b) Damped frequency of oscillation, (c) Critical value of resistance which will give no transient oscillation, (d) The value of resistance which will give damped frequency of oscillation, one-third of the natural frequency of oscillation. [8]
- b) Explain the working principle and operation of an SF6 circuit breaker, describing its construction and the role of SF6 gas in the arc quenching process. [8]
4. a) Referring to the following figure; given that fault current is 2000 A; Relay 1 set on 100%; CT ratio = 200/1; Relay 2 set on 125%; CT ratio = 200/1. For discrimination the time gradient margin between the relay is 0.5 second. [6]



Determine the time of operation of the two relay assuming that both relays have the characteristics as shown in the following table and the relay no. 1 has a time multiplier setting equal to 0.2. Also determine the time setting multiplier of relay 2.

PSM	2	3.6	5	8	10	15	20
Time for unity TSM	10	6	3.9	3.15	2.8	2.2	2.1

- b) A 15 MVA, 132/33 kV, delta-star 3 phase power transformer is protected by percentage differential relay. The CTs connected on HV and LV sides are 75/5 and 500/5 A respectively. The relay rating is 1 A. Determine: (i) the rated current of both sides, (ii) the relay current at full load, and (iii) the relay current at only 85 % loading. [6]
- c) Explain the working principle of an IDMT relay, including how it detects overcurrent conditions and the relationship between current setting, time delay, and time-current characteristics in IDMT relays. [6]
5. a) Describe the block diagram of the components of a static relay and explain how its design enhances speed and sensitivity in protection schemes. [8]
- b) What is the role of a directional static relay in power system protection? Explain the concept of a directional relay and its function in identifying the direction of fault current, supported by a block diagram. [8]

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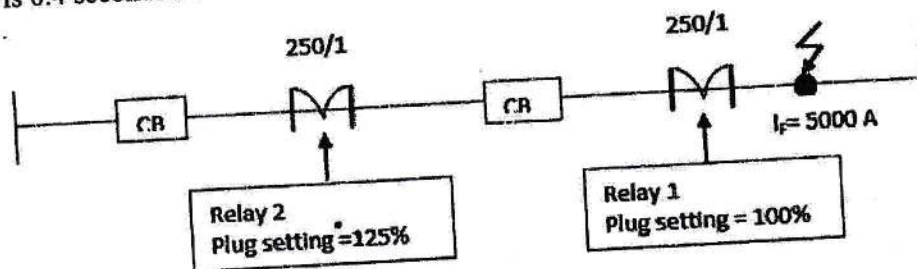


1. a) Explain the need for coordination between different protection schemes in a power system. How does improper coordination affect system performance? [6]
- b) Compare and contrast Potential Transformers (PTs) and Current Transformers (CTs) in terms of their construction, operating principles, and typical applications in power system protection and control. Highlight key differences in their usage and design. [5]
- c) Explain the working of dropout fuse. Also suggest in which side of a transformer will you keep this fuse and what will be its rating for a 11/0.4 kV – 200 kVA transformer. [5]
2. a) A 130 ampere current is flowing in the line given below. At the same time, we must do some repair works in this breaker. To work in the breaker, in which sequences should these switching devices operate and why? [6]



- b) A 33 kV, 3 phase 50 Hz, overhead line 80 km long has a capacitance to ground of each line equal to 0.015 μF per km. Determine the inductance and kVA rating of the peterson coil. [4]
- c) Discuss the different methods used for over voltage protection in electrical systems. [4]
3. a) A 50 Hz 3-phase alternator with grounded neutral has an inductance of 1.6 mH per phase and is connected to the bus-bars through a circuit breaker. The capacitance to earth of the circuit between the alternator and the circuit breaker is 0.0032 μF per phase. Due to a short on the bus-bars the breaker opens when the rms value of the current is 8,000 A. Determine the frequency of oscillations, active recovery voltage, time for maximum RRRV and maximum RRRV. [8]
- b) Discuss the advantages of using vacuum circuit breakers over oil and air circuit breakers, focusing on arc quenching, maintenance, and environmental impact. [8]
4. a) Discuss the advantages and limitations of static relays over electromagnetic relays. Also mention the main components of static relays and explain their role. [8]
- b) With the help of a block diagram, explain the functioning of static differential protection relay. [8]

5. a) The time multiplier setting of relay 1 is 0.3 and the time grading margin between the relays is 0.4 second. Determine the time of operation of two relays. [6]



PSM	2	3.6	5	9.23	13.33	16	20
Time in sec	10	6	3.9	2.9	2.8	2.2	2.1

- b) Explain the interaction between overcurrent relays and directional relays, including how they work together to protect transmission lines or feeders. [6]
- c) What are the different types of distance relays and what are their applications? Discuss the scenarios in which each type is used and the reasons for their selection. [6]

TRIBHUVAN UNIVERSITY
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2081 Ashwin

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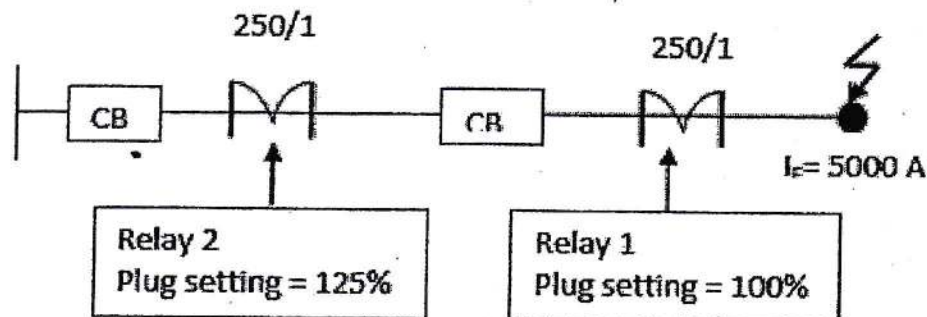
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1. a) Discuss the fundamental objectives and principles that guide the design of protection schemes in electrical power systems. [5]
- b) Why should the secondary winding of a CT installed in a substation not be open-circuited? Explain with Example. [5]
- c) Define drop out fuse and explain its operation and application area with an example. [6]
2. a) List down the different applications of contactor. With the help of necessary schematic circuit, explain how star-delta starting of motor can be achieved with the help of contactors. [6]
- b) Explain the purpose and function of overhead earth wires in overvoltage protection systems for electrical networks. [5]
- c) An inductor of 20 Henry is connected in the neutral connection of a 50 Hz, 33 kV, 3 phase line to neutralize the capacitive current. Calculate
 - i) The line to ground capacitance of each line.
 - ii) kVA rating of inductor coil. [5]
3. a) A 3 phase alternator has the line voltage of 11 kV. The generator is connected to a circuit breaker. The inductive reactance upto the circuit breaker is 5 ohm per phase. The distributed capacitance upto circuit breaker between phase and neutral is 0.1 μ F. Determine the (i) Peak restriking voltage across the circuit breaker. (ii) Frequency of restriking voltage transient. (iii) Average rate of restriking voltage upto peak restriking voltage, and (iv) Maximum RRRV. Neglect first pole to clear factor. [8]
- b) Describe the construction, operating principle and application of Minimum Oil Circuit Breaker. What are the advantages and disadvantages over SF6 Circuit Breaker? [8]
4. a) Determine the time of operation of both relays and the time multiplier setting of relay 2. The time multiplier setting of relay 1 is 0.2 and the time grading margin between the relays is 0.4 second. The relay characteristic is shown in the table. [6]

PSM	2	3.6	5	9	10	16	20
T (s)	10	6	3.9	2.9	2.8	2.2	2.1



- b) A three-phase transformer rated for 33kV/6.6kV is connected star/delta and the protecting current transformer on the low voltage side have a ratio of 400/5. Determine the ratio of the current transformers on H.V side. Draw the connection diagram showing how the relay operates under fault conditions. [5]
- c) Explain about the Overcurrent Protective Schemes used for the protection of distribution lines. [5]
5. a) Explain the principle of static differential relay with the help of block diagram. [8]
- b) Discuss the advantage and limitation of digital relays. Describe the functional block diagram of a digital relay. [8]

TRIBHUVAN UNIVERSITY
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1. a) Discuss the essential qualities of protection schemes and explain them in detail. [6]
 b) Write about different types of Potential Transformer (PT) based on construction. Draw a Phasor diagram for a CT. [5]
 c) Which fuse is best suited at high voltage side of a distribution transformer? Explain its operation. [5]
2. a) Draw the single line diagram (SLD) of a power system, discuss the function and working sequence of Isolators, Earthing Switch and Circuit Breaker. [6]
 b) Why the neutral in a power system grounded? Explain different methods of neutral grounding. [5]
 c) A 33kV, 3 phases, 60 Hz overhead line 70 km long has a capacitance to ground of each line equal to 0.015 μ F per KM. Determine the inductance and KVA rating of Peterson coil. [5]
3. a) Explain the phenomenon of interruption of capacitive current in a circuit breaker. [4]
 b) In a short circuit test on a 132 kv, three phase system, the breaker gave the following results. Pf of the fault is 0.4, recovery voltage is 0.9 of full line value and the natural frequency is 16 KHz. Determine the rate, if rise of restriking voltage in following cases. [6]
 i) Assume the symmetrical fault is grounded.
 ii) Assume that symmetrical fault is not grounded.
 c) Describe the construction, principle of operation and application of Vacuum Circuit Breaker. [6]
4. a) With neat diagram explain the principle of operation of an induction disc type over current relay. How can a directional feature introduce in the same? [8]
 b) A 50 MVA, 132/66 kV, Δ Y, three-phase power transformer is protected by percentage differential relays. If the current transformers (CTs) located on Δ and Y sides of the power transformer are 300/5 A and 1,200/5 A respectively, determine (i) the output at full load (ii) the relay current at full-load (iii) the minimum relay current setting to permit 25% overload. [8]
5. a) How static MHO relay is realized using a phase comparator? Explain with its characteristic. [8]
 b) Discuss the advantage and limitation of digital relays. Describe the basic functional blocks of a digital relay. [8]

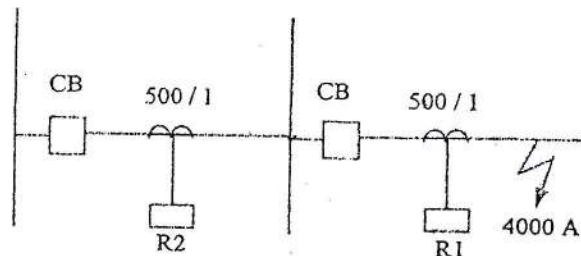
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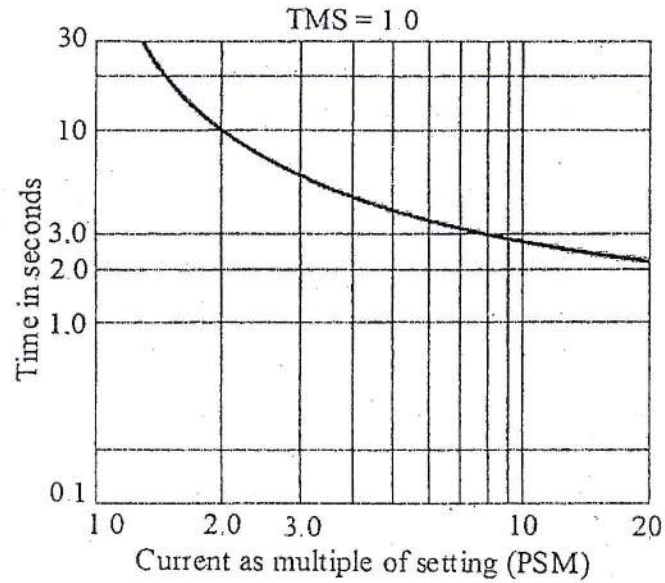
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1. a) Sketch a single line diagram of different protection zones used in power system. Why back up protection is provided? Explain with it's methods. [6]
- b) Explain CT burden and how is it specified? [4]
2. a) Explain operation and application area of drop out fuse. [6]
- b) Draw the single line diagram to connect a CB, Isolator, Earthing switches and write the sequence of operation while opening and closing of circuit. [6]
- c) The neutral point of a 11 kV alternator is earthed through a resistance of 12Ω , the relay is set to operate when there is out of balance current of 0.8 A. The CTs have a ratio of 2000/5. What percentage of the winding is protected against earth fault? What must be the minimum value of earthing resistance required to give 90% of protection to each phase? [6]
3. a) In a 132 kV system, the inductance and capacitance up to the location of the circuit breaker are 0.4 H and $0.015 \mu\text{F}$, respectively. Determine (i) the maximum value of the restriking voltage across the contacts of the circuit breaker, (ii) frequency of transient oscillation and (iii) the maximum value of RRRV. [6]
- b) Describe the testing methods of circuit breaker. [4]
- c) Describe the construction and working of puffer type SF₆ Circuit Breaker. Also mention the merits and demerits of SF₆ Circuit Breaker. [6]
4. a) Describe the principle of operation and area of application of an induction directional overcurrent relay with the help of a neat sketch. [6]
- b) Mention the difficulties associated with differential protection. Explain the Merz-Price protection for Star-Delta Power Transformer. [6]
- c) Determine the time of operation of the relays placed at location No. 1 and 2 assuming that fault current is 4000 amps, CT ratio 500/1, relay 1 set at 100% and 2 at 125% and the relay No. 1 has a time-multiplier of 0.2. The time grading margin between the relays is 0.4 sec for discrimination. Assume the relay to have 2.2 sec IDMT characteristics shown below. [8]



IDMT Characteristic:



Standard 2.2 sec IDMT curve

5. a) With the help of neat diagram explain the principle of static differential relay. [8]

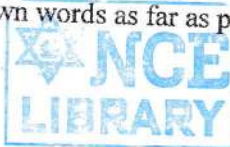
b) Write short notes on: [2×4]

- (i) Main components of static relay
- (ii) Level detector

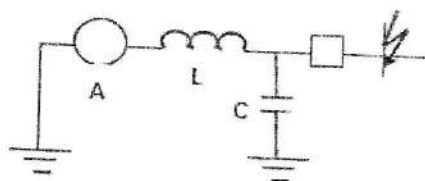
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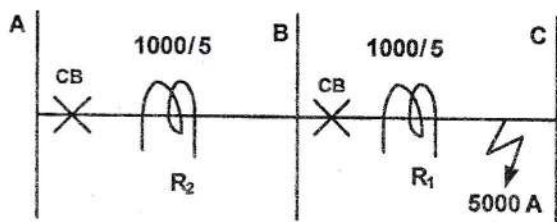
1. a) What are primary and back up protection? Explain the necessity of back up protection with an example. [5]
- b) What do you mean by typical knee point voltage in relation to CT? Briefly explain the different errors of CT and its causes. [5]
- c) Explain the operating characteristics of HRC fuse. How do these characteristics influence their applications in electrical systems? [6]
2. a) Discuss the constructional differences between isolators and contactors, focusing on key components and design considerations that enable their respective functions. [6]
- b) What are the causes of over voltages on power system? List the merits and demerits of solid grounding. [5]
- c) A 33 kV, 3 phase 50 Hz, overhead line 60 km long has a capacitance to ground of each line equal to $0.015 \mu\text{F}$ per km. Determine the inductance and kVA rating of the Peterson coil. [5]
3. a) A 3 phase 50 Hz alternator with grounded neutral is connected to a bus bar through a circuit breaker. Due to short circuit on the busbar the circuit breaker trips when the current is 7000 A (rms) as shown in figure. Determine (i) Active recovery voltage (ii) Frequency of oscillation (iii) Time to reach the peak restriking voltage (iv) Maximum RRRV. [8]



A = Alternator
L = 1.5 mH/phase
C = $0.0025 \mu\text{F/phase}$

- b) What is the purpose of incorporating arcing contacts alongside main contacts in circuit breakers? Also explain the function of arc runners and arc splitters within an air-break circuit breaker, supported by a clear diagram. [8]
4. a) Two relays R1 and R2 are connected in two sections of a feeder as shown in figure. CTs are of ratio 1000 / 5 A. The plug setting of relay R1 is 100 % and R2 is 125 %. The operating time characteristic of the relays is given below. The time multiplier setting of the relay R1 is 0.3. The time grading scheme has a discriminative time margin of 0.5 s between relays. A three phase short circuit at F results in a fault current of 5000 A. Find the actual operating times of R1 and R2. What is the time multiplier setting (TMS) of R2. [6]

Plug setting multiplier	2	4	5	8	10	15	20
Time in seconds for a time multiplier of 1	10	5	4	3	2.8	2.6	2.4



- b) A 220/110 kV - 150 MVA transformer is protected by percentage differential relay. The HV and LV sides are delta and star connected respectively. The CT ratio of delta side is 400/5 and the ratio of star side is 1600/5. Determine (i) The CT secondary currents at full load, (ii) The relay current at full load, (iii) The relay current setting for 90 % loading. [6]
- c) Explain the working principle of impedance type distance relay and also explain its application area. [4]
5. a) Discuss the advantages and limitations of static relays over electromagnetic relays. Also explain the main components of a static relay with the help of block diagram. [8]
- b) Explain the operating principles of static overvoltage and undervoltage relays. How do these relays detect abnormal voltage conditions and initiate protective actions to prevent equipment damage? [8]

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1. a) Why the protective zones are arranged in overlap fashion? Discuss in brief the various essential qualities of Protective Relaying. [6]
- b) Explain knee point voltage in CT with the help of necessary plots. Explain its importance in selection of CT for protection system. [5]
- c) Discuss the method of selecting the rating of HRC fuse in motor stator. [5]
2. a) Although CB can be used to isolate the circuit, why we need isolator? Explain why we use isolator and circuit breaker simultaneously, with a neat diagram. [6]
- b) Explain in detail about the need and different types of lighting protection scheme. [5]
- c) In a 50HZ overhead line, the capacitance of one line to earth was $1.5 \mu\text{F}$. It was decided to use an earth fault neutralizer. Calculate the reactance to neutralize the capacitance of (i) 100% of length of the line (ii) 90% of length of line. [5]
3. a) What is the difference between restriking voltage and recovery voltage? [4]
- b) A 50 Hz, 11 kV generator is connected to a power system. The system inductance and capacitance per phase are 10 mH and $0.02 \mu\text{F}$ respectively. Calculate: [6]
 - i) Maximum voltage across the contacts of the CB at an instant when it passes through zero.
 - ii) Frequency of transient oscillation.
 - iii) Average rate of rise voltage up to the first peak of oscillation, neglect the resistance.
- c) Describe with neat sketch the construction and principle of operation of a air blast circuit breaker. [6]
4. a) With neat diagram explain the various types of electromagnetic relays and their field of application. [8]
- b) A 20MVA transformer which is used to operate at 30% overload feeds an 11kV busbars through a circuit breaker. The transformer Circuit Breaker is equipped with a 1000/5 CT and feeder Circuit Breaker with 400/5 CT and both the CTs feeds IDMT relays having following characteristics: [8]

Plug Setting Multipliers	2	3	5	10	15	20
Time in Second	10	6	4.1	3	2.5	2.2

The relay on the feeder CB has 125% plug setting and a 0.3 Time Multipliers setting. If a fault current of 5000 A flows from the transformer to the feeder, Determine:

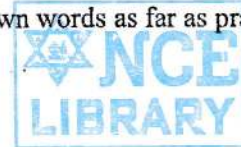
- i) Operating time of feeder relay
- ii) Suggest suitable plug setting and time multiplier setting of the transformer relay to ensure adequate discrimination of 0.5s between transformer and feeder relay.
5. a) Discuss the advantage and limitations of static relays over electromagnetic relays. Also mention the main components of static relay. [8]
- b) With the help of neat block diagram, explain the function of Directional Static Overcurrent relay. [8]

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1. a) The system of fig. 1(a) is rearranged as shown in fig.1 (b) where the bus arrangement at B has been changed to a ring bus arrangement. [6]
- i) Compare the operation of the two systems for when a fault occurs on line BC with
 - a. A failure of breaker 7.
 - b. A failure of breaker 6.
 - ii) Sketch the zone of protection.

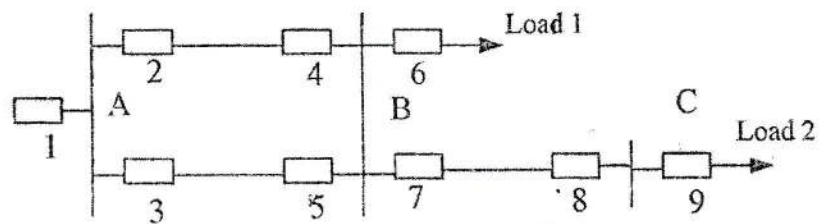


Fig.1 (a)

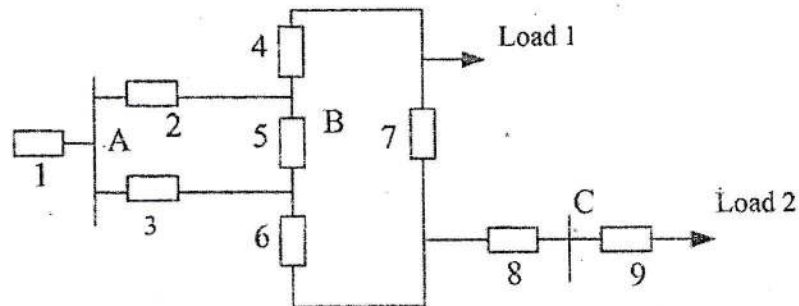
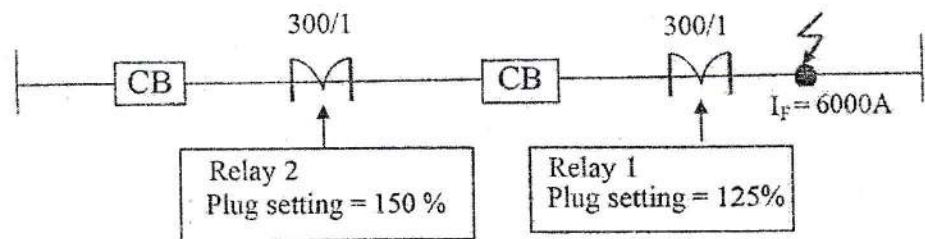


Fig.1 (b)

- b) A current transformer is connected in 400 V system and has 1 turn on its primary and 180 turns on its secondary. An ammeter with 0.15Ω internal resistance is connected to CT. The ammeter is required to give a full scale deflection when the primary current is 900 Amps. Calculate :
- i) The maximum secondary current
 - ii) Secondary voltage at CT terminals when ammeter is removed.

[4]

2. a) Explain the cut-off characteristics and the time-current characteristics of a fuse. [6]
 b) Explain the construction and operating principle of contactor. Draw the circuit diagram for remote control of a contactor. [6]
 c) Describe the protection of stations and sub-stations against direct lightning strokes. [6]
3. a) In a short circuit test on a 220 kV 3-phase system, the breaker gave the following results: p.f. of the fault 0.45, recovery voltage 0.9 of full line value; the breaking current is symmetrical and the restriking transient had a natural frequency of 18 kHz. Determine the rate of rise of restriking voltage. Assume that the fault is grounded. [6]
 b) Calculate breaking capacity in MVA and making capacity in kA of a 3 phase circuit breaker with following parameters.
 Rated current = 800A; Rated voltage = 33kV; $I_{bsym}=25$ kA [4]
 c) Describe the working of cross jet explosion pot in bulk oil circuit breaker with a neat sketch. [6]
4. a) Explain the working of gas operated Buchholz relay used for the protection of a transformer. State its limitations and advantages. [6]
 b) A 3-phase transformer rated for 33 kV/6.6 kV is connected star/delta and the protecting current transformer on the low voltage side have a ratio of 400/5. Determine the ratio of the current transformer on the HV side. [6]
 c) The time multiplier setting of relay 1 is 0.2 and the time grading margin between the relays is 0.3 second. Determine the time of operation of two relays. [8]



ISM	2	3.6	5	9.23	13.33	16	20
Time in sec	10	6	3.9	2.9	2.8	2.2	2.1

5. a) Name the different types of Static Relays. Discuss the advantage and disadvantage of Static Relay as a protective device. [8]
 b) With the help of a block diagram explain the functioning of static distance relay. [8]

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2077 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Switchgear and Protection (EE 651)

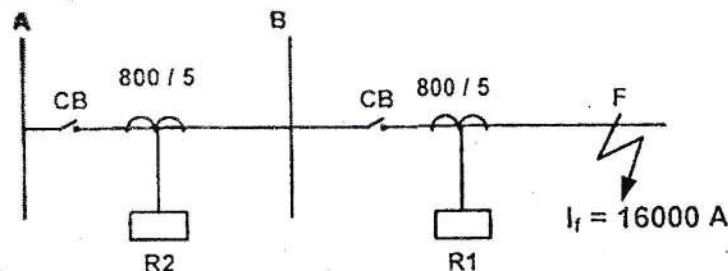
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) Explain briefly about primary and backup protection. [6]
 - b) Why voltage Transformer are required in Protection system. Also describe the construction of CCVT? [4]
 - c) Define fusing current and current carrying capacity of a fuse with an example. [6]
2. a) How contactors are used to control and protect the motor? Explain the working principle of scheme with suitable necessary circuit. [5]
 - b) Explain the methods of overvoltage protection of electrical equipments. [5]
 - c) A 90km long 66kV, 50Hz, 3 phase overhead line has capacitance to earth equal to $0.02 \mu\text{F}$ per km. What should be the inductance and kVA rating of the arc suppression coil. [6]
3. a) Determine the rated symmetrical breaking circuit, making current and short time rating of a circuit with following parameters. [4]

33kV, 1500A, 3000MVA, 1sec

 - b) Define following terms:
 - (i) Recovery voltage
 - (ii) Re-striking voltage
 - (iii)RRRV

Also, derive an expression for the restriking voltage in terms of system inductance and capacitance. [6]
 - c) Describe the construction and working principle and application area of a vacuum circuit breaker. [6]
4. a) As shown in figure, the relay at B has a plug setting of 125% and TMS of 0.2. The circuit breakers take 0.20sec to clear the fault and the relay error in each case is 0.15 sec. For a plug setting of 200% on the relay A, determine the minimum TMS on that relay for it not to operate before the circuit breaker at B has cleared the fault. A relay operating time curve shown in table. [6]



IDMT characteristic:

PSM	2	3.5	5	6.5	8	10	12	14	16
Operating Time (sec)	10	6	5	4	3.15	3	2.9	2.5	2

- b) What is an impedance relay? Explain its operating principle, torque equation and operating characteristics for impedance relay? [6]
- c) A 3 phase 66000/6600 V star/delta transformer is protected by Merz-Price system. What will be the ratio of current transformer is protected by Merz-Price system. What will be the ratio of current transformer on the high voltage side if the current transformers on the low voltage side have a ratio of 400/5 A. [4]
5. a) Explain the working principle of static differential relay with the proper block diagram and circuit diagram. [8]
- b) Define comparator and explain its types used in static relay. [8]



2076 Bhadra



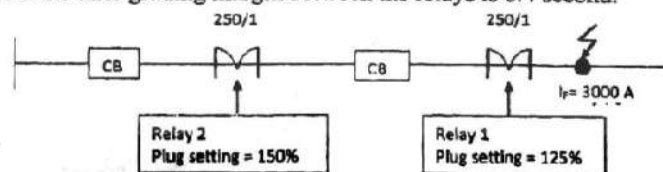
TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2076 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Switch gear and Protection (EE 651)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) List down the basic requirements of good protective scheme. What do you understand by coordination of protective device and protection zone? [6]
 b) Explain the need of capacitive voltage transformer in power system. [4]
 c) What are the considerations in selecting a fuse for (i) Transformer protection (ii) capacitor protection (iii) lighting loads [6]
2. a) Explain with a neat sketch how automation of a system is done with the help of a contactor. [6]
 b) What are the causes over voltages on power system? List the merits and demerits of solid grounding. [5]
 c) Calculate the inductance and kVA rating of the arc suppression coil of a 50 km long 33 kV, 50 Hz, 3 phase overhead transmission system having line to earth capacitance of each phase equal to $0.0125 \mu\text{F}$. $L = 25.4 \text{ mH}$ / 213.96 kVA [5]
3. a) A 50 Hz 3 phase alternator with grounded neutral has an inductance of 1.6 mH per phase and is connected to the bus-bars through a circuit breaker. The capacitance to earth of the circuit between the alternator and the circuit breaker is $0.0032 \mu\text{F}$ per phase. Due to a short on the bus-bars the breaker opens when the rms value of the current is 8000 A. Determine the following (i) frequency of the oscillation (ii) active recovery voltage (iii) time for maximum RRRV (iv) maximum RRRV [6]
 b) Explain the construction and working of SF_6 circuit breaker. Also enumerate the dielectric properties and arc quenching characteristic of SF_6 circuit breaker with their limitations. [6]
 c) What are the main parts of equipment which are used for the testing of a circuit breaker in a laboratory type testing station? [4]
4. a) Determine the time of operation of two relays assuming that both the relays have the characteristics as shown in the following table. The time multiplier setting of relay 1 is 0.18 and the time grading margin between the relays is 0.4 second. [6]



PSM	2	3.6	5	9.23	10	15	20
Time in sec	10	6	3.9	2.9	2.8	2.2	2.1

- b) A 11kV, 100 MVA generator is grounded through a resistance of 6Ω . The CTs have a ratio of 1000/5. The relay is set to operate when there is an out of balance current of 1A. What percentage of the generator winding will be protected by percentage differential scheme of protection? 31.10% [6]
- c) Discuss the principle of operation of an induction disc relay with the help of a neat sketch. [4]
5. a) Define phase comparator and explain the types of comparators used in static relays. [8]
 b) Explain the working of static MHO relay with the help of block diagram. [8]

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

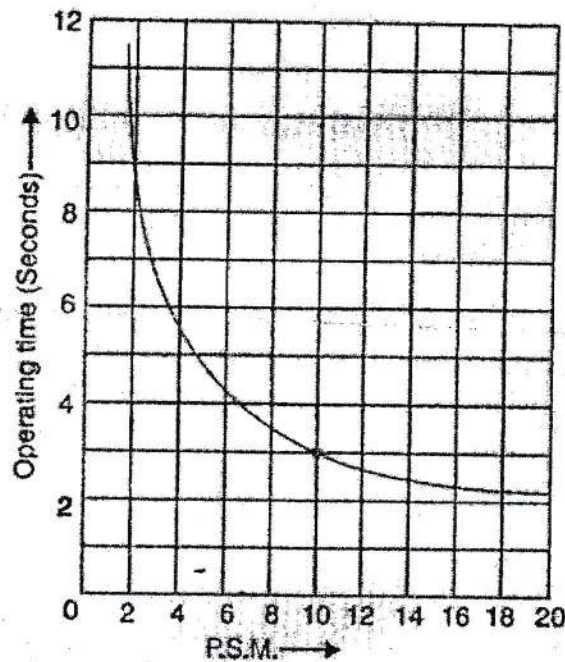
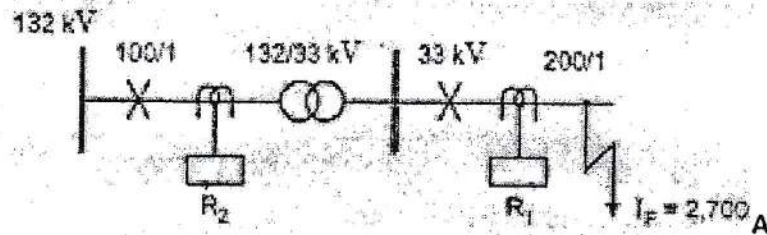
Subject: - Switch Gear and Protection (EE651)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) What are the basic requirements of protection scheme? Differentiate between a protective system and protective scheme. [6]
- b) Explain why the secondary of CT should not be left open and secondary of PT should be short circuited. [4]
- c) Write short notes on the following: [3+3]
 - i) Low voltage HRC fuse
 - ii) Drop-out fuse
2. a) What are the basis difference between Isolator and circuit breaker? Explain why we use isolator and circuit breaker simultaneously? [6]
- b) A 33 kV, 3 phase 50 Hz, overhead line 60 km long has a capacitance to ground of each line equal to 0.015 μ F per km. Determine the inductance and KVA rating of the peterson coil. [5]
- c) What are the factors affecting soil resistivity? How can we reduce earth resistance? [5]
3. a) The system inductance per phase of a system is 8 mH and the frequency of transient oscillation is 10.273 kHz. If a 50 Hz, 6.6 kV generator is connected to that system. Calculate: [4]
 - i) Max voltage across the contacts of the CB at an instant when it passes through zero.
 - ii) System capacitance per phase
 - iii) Average rate of rise of voltage up to the first peak of oscillation, neglect resistance
- b) Compare the performance and characteristics and working principle of : [8]
 - i) Minimum oil circuit breaker Vs Back oil circuit breaker
 - ii) Air blast circuit breaker Vs puffer types SF6 circuit breaker
- c) Explain the operation of auto reclosure. [4]
4. a) Describe the construction and principle of operation of induction type directional over-current relay. Explain IDMT characteristics and how they are obtained in an induction type relay. [8]
- b) A 125 MVA, 220/132 kV three phase power transformer is protected by percentage differential relays. The current transformers located on HV and LV sides of the power transformer are 400/5 A and 1200/5 respectively. If the HV side is delta connected and the LV side is star connected, determine: [4]
 - i) The output line currents of both CT at full load
 - ii) The relay current at 15% overload
 - iii) The minimum relay current setting to permit 25% overload

- c) It is given that fault current level at 33KV side is 2700A, CT ratio at 33 KV side is 200:1 and 132 KV side is 100:1 (figure below). If both the relays R1 and R2 are set for 100% plug setting, determine the operating time for both the relays when time grading margin of 0.6 second is given and TMS for relay R1 is 0.15. (PSM/Operation Time graph is given below)

[4]



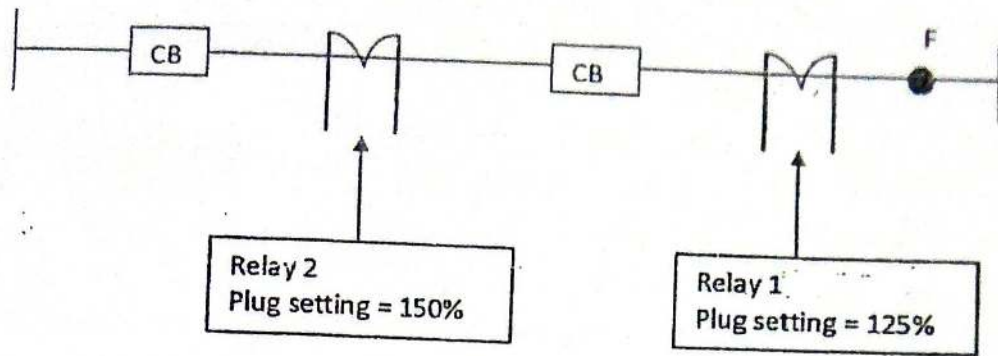
5. a) Explain essential components of a static relay with block diagram. [8]
 b) Explain carrier current protection and bus bar protection with suitable diagram. [8]

Exam.	Back		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Switch gear and Protection (EE651)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) Explain the fault clearing process with the help of trip circuit. [6]
- b) Explain the need of Instruments transformers in system. Mention the errors on CT. [4]
- c) Describe the time / current I^2T characteristics of a HRC fuse and explain how they are used to select the ratings of fuses in series. [6]
2. a) What is isolator? With the single line diagram, explain the working of isolator with consideration of closing and opening of circuit breaker kept in high voltage installation? [2+4]
- b) Why the neutral in a power system grounded? Explain different methods of neutral grounding. [5]
- c) A 33KV, 3 phases, 50 Hz overhead line 60 km long has a capacitance to ground of each line equal to $0.015\mu F$ per Km. Determine the inductance and KVA rating of Peterson coil. [5]
3. a) Describe the construction, principle of operation and application of vacuum circuit breaker. [8]
- b) Explain the terms related to Circuit Breaker i) Making Capacity ii) Breaking Capacity iii) Operation Duty iv) Rated Current [4]
- c) Explain operation of HVDC circuit Breaker. [4]
4. a) What are the various types of over current relays? Discuss their area of application. [4]
- b) Explain distance protection relay. Mention their applications. [6]
- c) Calculate the time of operation of relay 1 and time setting multiplier for relay 2 for the conditions given below. [6]
 - (i) Time grading margin between the relays is 0.5 sec
 - (ii) The time setting multiplier of relay 1 is 0.4
 - (iii) CT ratio of both CTs is 300/1
 - (iv) The fault occurs at point F and fault current is 3000A.
 - (v) Time current characteristic of both relays is given in table



PSM	2	3.6	5	6.67	8	10	15	20
Time in sec	10	6	3.9	3.5	3.15	2.8	2.2	2.1

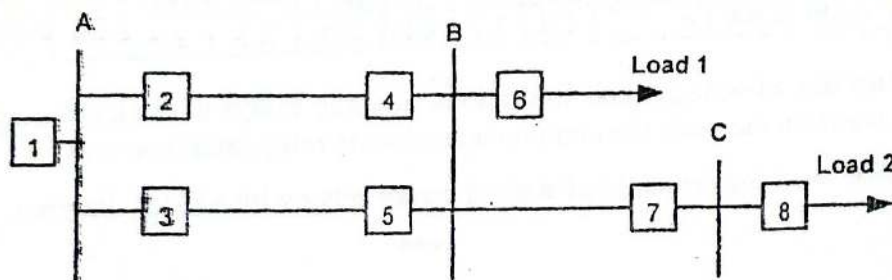
5. a) With the help of neat block diagram, explain the function of directional static over current relay. [8]
- b) Draw the block diagram of microprocessor based protective scheme for protection of transmission line. [8]

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Switch gear and Protection (EE651)

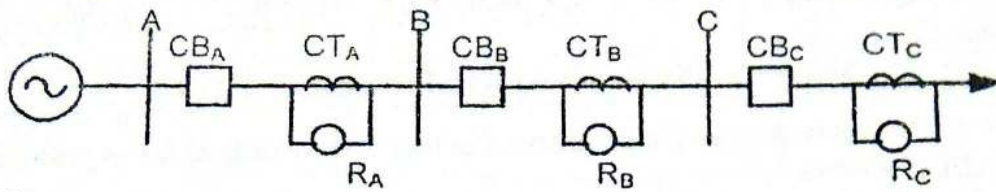
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) Consider the system portion shown in figure below. (i) Sketch the zone of protection (ii) Describe a possible backup scheme for failure of breaker 7 for a fault on line BC, is load 1 interrupted. (iii) Describe a means of clearing a fault on line BC without a momentary interruption of load 1. [6]



- b) Define current transformer its working principle and their application areas. [4]
- c) Explain the construction and operation of HRC fuse. Also mention the difference between Fuse and MCB. [3+3]
2. a) What are the basic difference between Isolator and circuit breaker? Explain why we use isolator and circuit breaker simultaneously? [6]
- b) What is neutral earthing? Briefly discuss different types of neutral earthing. [6]
- c) Determine the inductance and kVA rating of the arc suppression coil for a 60 km long 33 kV, 50 Hz, 3 phase overhead line having capacitance to earth equal to $0.015 \mu\text{F}$ per km. [4]
3. a) A 50 Hz, three-phase synchronous generator has an inductance per phase of 1.7 mH and its neutral is grounded. It feeds a line through a circuit breaker. The total stray capacitance to ground of the generator and circuit breaker is $0.0025 \mu\text{F}$. A fault occurs just beyond the circuit breaker, which opens when the symmetrical short circuit current is 7500 A. (rms). Ignoring the first pole to clear factor, determine the following. (i) Natural frequency of Oscillations. (ii) Peak value of TRV (iii) Time at which peak value of TRV occurs (iv) Maximum rate of rise of TRV (v) Time at which the maximum in part (a) occurs. [8]
- b) Describe the construction and working of a puffer type SF₆ circuit breaker. Also mention the properties of SF₆ gas which make it a good arc quenching medium. [8]
4. a) Describe how an overcurrent and earth-fault protection scheme by IDMT relays for a transformer could be converted into the form of differential protection. What are the advantages over the other protection schemes are as applied to transformer. [8]

- b) IDMT relays for protection of sectionalised radial feeder shown in figure below and the method of selection of their settings are given below. Time setting multiplier is 1. [8]



Relay Point	CT ratio	Fault current	Current setting
A	400 / 5	4000 A	100 %
B	300 / 5	3000 A	75 %
C	200 / 5	2000 A	50 %

IDMT Characteristics.

PSM	2	4.2	6.5	8.8	10	12.4	13.3	16.3	18	20
Time in sec	8	4.2	3.8	3.1	2.8	2.6	2.5	2.4	2.3	2.2

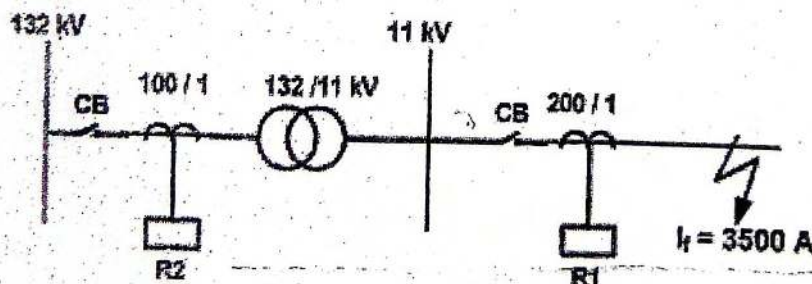
5. a) Discuss the advantages and limitations of static relays over electromagnetic relays? Also mention the main the components of static relays and their role. [8]
- b) Describe working principle of static distance relay with a block diagram. [8]

Exam.	New Back (2066 & later batch)		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Switch Gear and Protection (EE651)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) State the various methods used to provide backup protection. [4]
b) What is the purpose of a CT? Draw a phasor diagram and explain briefly what are the ratio and phase angle error of CT? [1+3]
2. a) What factors govern the time-current characteristics of a fuse link? Explain what is meant by "fuse coordination.". [6]
b) How contactor are used to control and protect the motor? Explain the working principle of scheme with suitable necessary circuit. [6]
c) Why the neutral in a power system grounded? Explain. [4]
d) A 33KV, 3 phases, 50 Hz, 60 km long overhead line has a capacitance to ground of each line equal to $0.015\mu\text{F}$ per Km. Determine the inductance and KVA rating of Peterson coil. [4]
3. a) For a 132 kV system, the reactance and capacitance up to the location of circuit breaker is 5Ω and $0.035\mu\text{F}$, respectively. A resistance of 350Ω is connected across the contacts of the circuit breaker. Determine the (a) Natural frequency of oscillation (b) Damped frequency of oscillation (c) Critical value of resistance which will give no transient oscillation and (d) The value of resistance which will give damped frequency of oscillation, one-third of the natural frequency of oscillation. [8]
b) Explain the high resistance and current zero interruption method of arc extinction in the circuit breakers. What is the criteria for successful arc interruption? [8]
4. a) With a neat sketch explain the operation of differential protection scheme for a power transformer. [6]
b) Two Relays R1 and R2 are connected in two sections of a feeder shown in figure below. Fault current level at 11 kV side is 3500 A, CT ratio at 11 kV side is 200:1 and 132 kV side is 100:1. If R₁ set on 125% and R₂ set on 150% plug setting. Determine the operating time for both the relays when time grading margin of 0.75 second is given and TMS for relay R1 is 0.25. Make use of the following characteristics. [8]



IDMT Characteristic:

PSM	2	4.6	5.33	6.73	8.2	10	12.3	13.6	15
Operating time (sec)	10	5	4.5	4	3.15	2.8	2.5	2.3	2

- c) What are the different types of electromagnetic relays? Discuss their field of applications. [6]
5. a) Explain essential components of a static relay with block diagram. [8]
- b) Write short notes on: [4×2]
- i) Level detectors
 - ii) Use of operational amplifier in static relay

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Switch Gear and Protection (EE651)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

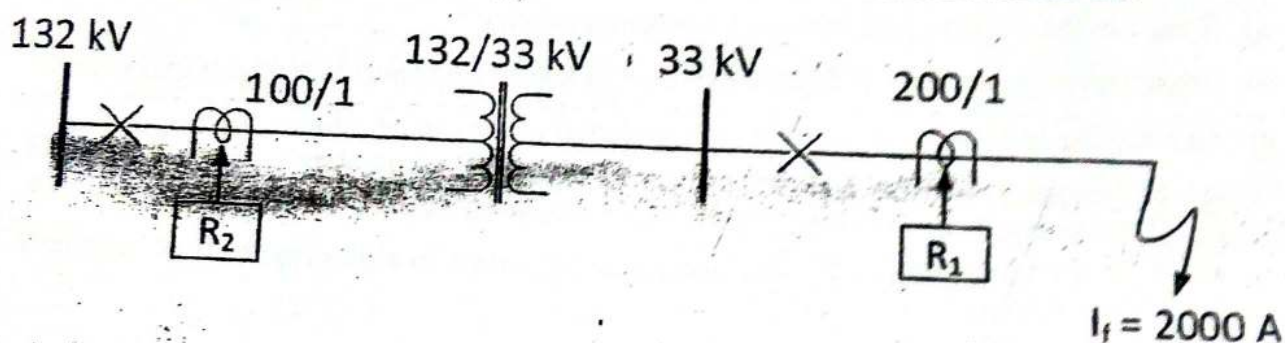
1. a) What are the basic requirements of protection scheme? [4]
- b) What are the main facts to distinguish current transformer and potential transformer? [4]
2. a) Explain the following terms showing the sketch of the cut off characteristics of fuse. [6]
 - i) Minimum fusing current
 - ii) Rated current
 - iii) Perspective current
 - iv) Cutoff current
 - v) Fusing factor
- b) Explain the construction, operating principle and application of isolator. [6]
- c) An alternator rated at 10 kV protected by the balanced circulating current system has its neutral grounded through a resistance of 10 ohms. The protective relay is set to operate when there is out of balance current of 1.8 A in the pilot wires, which are connected to the secondary windings of 1000/5 ratio current transformers. Determine: [8]
 - (i) the percentage winding which remain unprotected
 - (ii) The minimum value of earthing resistance required to protect 80% of the winding.
3. a) Explain what do you understand by: [3+5]
 - i) Rated symmetrical breaking current
 - ii) Making capacity
 - iii) Short time current rating

Obtain their value for a three phase CB rated as 500 A, 500 MVA, 11 kV, 3 sec
- b) Explain the construction and working principle of SF6 circuit breaker. [6]

4. a) It is given that fault current level at 33 kV side is 2000 A. CT ratio at 33 kV side is 200:1 and 132 kV is 100:1 as shown in figure below. If the both relay R_1 and R_2 are set for 100% plug setting, determine the operating time for both relays assuming that both the relay have same characteristics as shown in table below. For the discrimination the time gradient margin between two relays is 0.5 second and the time setting multiplier for R_1 is 0.2. Also determine the time setting multiplies for R_2 .

[8]

PSM	2	3.6	5	8	10	15	20
Time in second for TMS=1	10	6	3.9	3.15	2.8	2.2	2.1



- b) A three phase, 11/132 kV, delta-star connected power transformer is protected by differential protection. The CTs on the LV side have a current ratio of 200/1. What must be the current ratio of the CTs on the HV side? How the CTs on both the sides of the transformer are connected.
- c) Explain with a neat sketch the percentage differential protection of an alternator.
5. a) Explain the working of static differential relay with the proper block diagram and circuit diagram.
- b) Discuss the advantages of digital relays. Describe the basic functional blocks of a digital relay.

[6]

[8]

[8]

[8]

Exam.	BE	Full Marks	80
Level	BE	Pass Marks	32
Programme	BEL	Time	3 hrs.
Year / Part	III / II		

Subject: - Switchgear and Protection (EE651)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) Write down the basic requirements of a good protective scheme of power system. [4]
 b) What are the applications of CTs and PTs in power system? What is the meaning of burden on CT? [4]
 c) Write the types of MCB used in resistive load and inductive loads. Why? [6]
2. a) Explain the constructional details of HRC fuse. State advantages of HRC fuse. [6]
 b) A transmission line has a capacitance of 0.1 microfarad per phase. Determine the inductance of Peterson coil to neutralize the effect of capacitance of (i) complete length of (ii) 90% length of the line. $f = 50$ Hz [4]
 c) What is chemical earthing? Write the factors affecting the earth resistance. [4]
3. a) Describe with a neat sketch the principle of operation of a minimum oil circuit breaker. Why is it called so? [8]
 b) In a 220 kV system the reactance and capacitance up to the location of circuit breaker is 8Ω and $0.025 \mu F$, respectively. A resistance of 600Ω is connected across the contacts of the circuit breaker. Determine the following: (i) Natural frequency of oscillation, (ii) Damped frequency of oscillation, (iii) Critical value of resistance which will give no transient oscillation and (iv) The value of resistance which will give damped frequency of oscillation, one-fourth of the natural frequency of oscillation. [8]
4. a) What is meant by percentage bias? How is this achieved in practice in differential relay? Under what circumstances is a percentage differential relay preferred over the differential relay? [6]
 b) Explain IDMT characteristics and working principle of induction disc relay. [7]
 c) IDMT characteristics of the relay are shown in figure below. Design the time-current grading of the system as given below. TSM at the relay Z is 0.1. Time setting multiplier is 1. [7]



Relay Point	C.T. ratio	Fault current	Current Setting
X	400 / 5	5000 A	125%
Y	200 / 5	4000 A	125%
Z	200 / 5	2000 A	100%

IDMT Characteristic:

PSM	2	4	6	8	10	12	14	16	18	20
Time in sec	8	4	3.6	3	2.8	2.6	2.4	2.2	2	2

5. a) Explain essential components of a static relay with block diagram. [8]
 b) Describe with neat block diagram, the microprocessor based relaying scheme for the protection of generator by monitoring the field current of the alternator. [8]

Exam.	BE	Regular	
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 HRS.

Subject: - Switchgear and Protection (EE651)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) Draw the protection zone diagram for a sample power system network and explain its rules. [4]
 - b) What are the different errors of CT? Explain briefly. [4]
 2. a) Explain the construction and operating principle of contactor. [6]
 - b) What are the basic difference between isolators and circuit breaker? With good circuit diagram why we use isolator and circuit breaker simultaneously in power system? Explain. [6]
 - c) The neutral point of a three-phase 20 MVA, 11 kV alternator is earthed through a resistance of 5Ω , the relay is set to operate when there is an out of balance current of 1.5 A. The CTs hence a ratio 1000/5. What percentage of winding is protected against an earth fault and what should be the minimum value of earthing resistance to protect 90% of the winding. [8]
 3. a) Describe arc extinction process in vacuum circuit breakers. Also explain the preferred voltage levels of its application and its advantages over OCB and air blast circuit breakers. [8]
 - b) In a short circuit test on a 132 kv, three phase system, the breaker gave the following results. Pf of the fault is 0.4, recovery voltage is 0.9 of full line value and the natural frequency is 16 KHz. Determine the rate of rise of restriking voltage in following cases. [8]
 - i) Assume that symmetrical fault is grounded.
 - ii) Assume that symmetrical fault is not grounded.
 4. a) State the difference between circulating current differential protection and balanced voltage differential protection with reference to behavior of CTs. [6]
 - b) A 20 MVA transformer which is used to operate at 30% overloads feeds an 11kv busbar through a CB. The transformer CB is equipped with a 1000:5 CT and both the CTs are feed IDMT relays having following characteristics. IDMT characteristic [8]

PSM	2	3	5	10	15	20
T.op.sec	10	6	4.1	3	2.5	2.2
- The relay on the feeder CB has 125% plug setting and a 0.3 time multiplier setting. If a fault current of 5000A flows from the transformer to the feeder, determine:
- i) Operating time of feeder relay
 - ii) Suggest, suitable plug setting and time multiplier setting of the transformer relay to ensure adequate discrimination of 0.5 sec between the transformer relay and feeder relay.
 - c) Draw the circuit diagram of unit protection scheme and explain its operation principle and give its application. [6]
 5. a) Describe static distance relays and their area of application. [8]
 - b) What do you understand by amplitude comparator and phase comparator? Write short notes on (i) Time Delay Circuits and (ii) Level Detector. [8]

Subject: - Switchgear and Protection (EE651)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) Define the following terms with reference to protection system. [4]
 - i) Back up protection
 - ii) Co-ordination
- b) What are the various accuracy class of CT? List out current error, phase displacement error and composite error for each class. [4]
2. a) An induction motor is required to protect through a fuse and contactor. Suggest a suitable guide line for selection of ratings of fuse and contactor. State any assumptions you make. [6]
- b) A 11 kV voltage feeder has a circuit breaker and isolator. Develop a guideline for connecting and disconnecting the feeder through isolator and circuit breaker. Can you replace circuit breaker with contactor in the feeder? Justify your answer. [3+3]
- c) A 13.8 KV, 125 MVA, star-connected alternator has a synchronous reactance of 1.4 per unit per phase and negligible resistance. It is protected by a Merz-Price balanced current system which operates when out-of-balance current exceeds 10% of the full load current. If the neutral point is earthed through a resistance of 2 Ω , determine what proportion of winding is protected against earth fault. [8]
3. a) Select a circuit breaker for the following applications 6.6 KV, 650 MVA (breaking capacity) breaker. It is supposed to be connected to primary of 6600/433 V, 2000 KVA transformer. Justify your choice and prepare the specifications for the breaker. [8]
- b) Compare the performance and characteristics of [8]
 - i) minimum oil circuit breaker and air blast CB
 - ii) Air-blast circuit breaker and back oil circuit breaker
4. a) A 10 MVA, 132/33 KV, star-delta, three-phase, 50 Hz transformer is connected in delta on the low voltage side and in star with star point earthed on the high voltage side. If the CTs on the high voltage have a ratio of 75/1 A, determine the CT ratio on the low voltage side. What would be the current circulating through pilots for a through fault due to which a current of 5 times the full load occurs if the voltage tapping is set to 128 KV at the time of occurrence of fault? [8]
- b) Explain the following types of protection with suitable diagrams [8]
 - i) Carrier current protection
 - ii) Bus-bar protection
- c) Draw the connection diagram of combined phase fault and earth fault protection scheme applied to the generator. [4]
5. a) Discuss the essential components of static relay. [8]
- b) Draw the block diagram of microprocessor based protective scheme for protection of transmission line. [8]

Exam.	BE	Full Marks	80
Level	BE	Pass Marks	32
Programme	PEL	Time	3 hrs.
Year / Part	III / II		

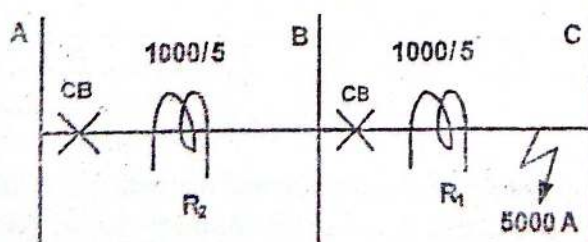
Subject: - Switchgear and Protection (EE651)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) What do you understand by a zone of protection? Discuss various zones of protection for a modern power system. [4]
- b) Describe the construction of capacitor voltage transformer. [4]
- c) What is an isolator? Write its function and application in power system. [6]
2. a) In relation to a fuse, explain what do you mean by (i) prospective current (ii) cut-off current (iii) time delay fuse. [6]
- b) Define causes of overvoltage and explain methods of overvoltage protection of electrical equipments. [8]
3. a) A 50 Hz 3-phase alternator with grounded neutral has an inductance of 1.6 mH per phase and is connected to the bus-bars through a circuit breaker. The capacitance to earth of the circuit between the alternator and the circuit breaker is 0.0032 μ F per phase. Due to a short on the bus-bars the breaker opens when the rms value of the current is 8000 A. Determine the following (i) frequency of oscillation (ii) Active recovery voltage (iii) time for maximum RRRV and (iv) maximum RRRV. [8]
- b) Describe with a neat sketch the construction and principle of operation of a SF₆ circuit breaker. [8]
4. a) What is Universal Torque Equation? Using this equation derive the following characteristics (i) impedance relay (ii) reactance relay (iii) mho relay. [8]
- b) Two relays R₁ and R₂ are connected in two sections of a feeder as shown in figure. CTs are of ratio 1000/5 A. The plug setting of relay R₁ is 100% and R₂ is 125%. The operating time characteristic of the relays is given below. [8]

The time multiplier setting of the relay R₁ is 0.3. The time grading scheme has a discriminative time margin of 0.5 s between relays. A three phase short circuit at F results in a fault current of 5000 A. Find the actual operating times of R₁ and R₂. What is the time multiplier setting (TMS) of R₂.

Plug setting multiplier	2	4	5	8	10	15	20
Time in seconds for a time multiplier of 1	10	5	4	3	2.8	2.6	2.4



c) A three phase 33/6.6 KV star/delta connected transformer is protected by differential system. The CTs on LT side have a ratio of 300:5. Find the ratio of the CTs on the HT side.

[4]

5. a) Name different types of static relays. Discuss the advantages and disadvantages of static relays as protective device.

[8]

b) Discuss the advantages of digital relays. Describe the basic functional blocks of a digital relay.

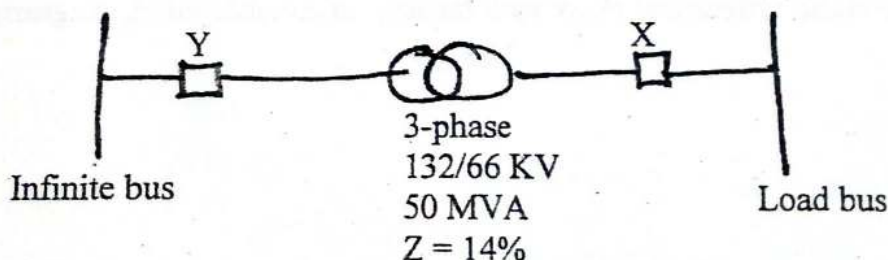
[8]

Exam.	New Back (2066 & Later Back)		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Switchgear and Protection (EE651)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) What are the basic requirements of any protection scheme in a power system? Explain them with the help of suitable example. [4]
- b) Discuss the causes of ratio error and phase angle error in PT. [4]
2. a) A transformer having capacity of 250 KVA, 11/0.415 KV, percentage impedance of 4.75% is required to be protected with fuses. Suggest guide line for selection of HV and LV side fuses. State any assumptions you make. [6]
- b) With reference to a single line diagram of a power system, discuss the function of isolator. Also mention the application of contractors in power system. [6]
- c) A 5000 KVA, 6600 V, star-connected alternator has a synchronous reactance of 2Ω per phase and 0.5Ω resistance. It is protected by Merz price balanced current system which operates when out of balance current exceeds 30% of load current. Determine what proportion of a alternator winding is unprotected if the star is earthed through a resistance of 6.5Ω . [8]
3. a) Figure shows a 132/66 KV power transformer is fed from an infinite bus. [8]

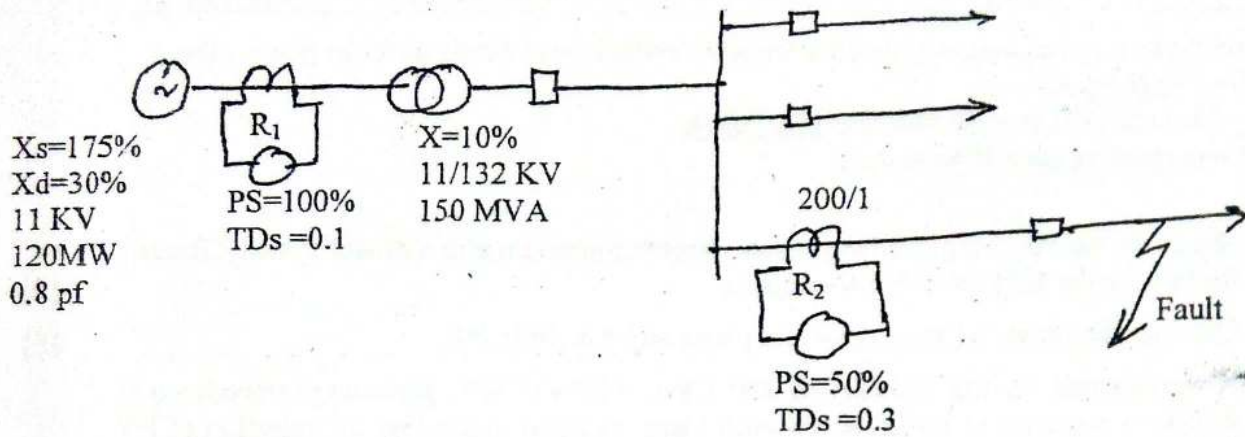


If the 66 KV bus is a load bus, specify for the breaker 'X'

- i) Rated continuous current
- ii) Breaking capacity in MVA
- b) Compare the merits and demerits of bulk oil circuit breakers, minimum oil circuit breakers and air blast circuit breakers. [8]

4. a) Figure shows a portion of power system in a single line diagram. Find out the time of operation of relays R_1 and R_2 for a fault immediately after relaying point R_2 . Relay R_1 is voltage monitored over current relay, the plug setting (PS) which reduces to 40% of the set value if voltage collapses below 70% of rated voltage.

[8]



PSM	2	3	5	10	15	20
Time (sec)	10	6	4.1	3	2.5	2.2

(Assume suitable data if necessary)

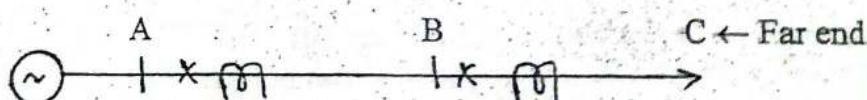
- b) Starting from the universal torque equation, explain the operation of impedance relay used for the protection of feeder. [8]
- c) Draw the connection diagram of restricted earth fault protection scheme for a generator with solidly grounded. [4]
5. a) Compare the static and electro-magnetic relays. [8]
- b) Discuss the static differential relay with the help of suitable block diagram. [8]

Exam.	BE	Full Marks	80
Level	BE	Pass Marks	32
Programme	BEL	Time	3 hrs.
Year / Part	III / II		

Subject: - Switchgear and Protection (EE651)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) Why protection system is needed in electrical power system? State and explain various causes of electrical faults. [4]
- b) What is 'knee point voltage'? Mention the difference between measuring and protective CT. [4]
- c) What is the main difference between Fuse and MCB? Define the following terms for HRC fuse: (i) cut off (ii) pre-arcing time (iii) arcing time. [2+2+2+2]
2. a) How contactors are used to control and protect the motors? Explain the working principle of the scheme with necessary circuits. [6]
- b) Why the neutral in a power system is grounded? What are the methods of grounding a neutral? Explain one of them in detail. [6]
3. a) A circuit breaker is rated as 2500 A, 1500 MVA, 33 KV, 3 sec, 3 phase OCB. Determine (i) the rated symmetrical breaking current (ii) rated making current (iii) short time rating and (iv) rated service voltage. [2+2+2+2]
- b) What is the most important basis for the classification of circuit breaker? How they are classified describe briefly. Mention their field of application. [8]
4. a) Explain with a neat sketch the percentage differential protection of an alternator. [8]
- b) Design a time-current graded protection scheme based on two identical IDMT relays at points A and B for the following radial feeder. Select appropriate current tap setting and time dial settings for the relays. Find out actual time of operation of relay at A for fault in its zone and as back up. Relay at A should also back up for faults at protection zone of B. [8]



Given:

Relay point	CT ratio	Fault current, A
A	300/5	4000
B	200/5	3000
Far end of feeder at point C		2000

IDMT Characteristics

PSM	2	3.6	5	8	10	15	20	
T.op. sec	10	6	3.9	3.15	2.8	2.2	2.2	(for TDS = 1)

- c) How does Buchholz relay protect the internal faults of transformer? [4]
5. a) State and explain various functional circuits of a static relay with the help of block diagram and explain the function of each block. [8]
- b) Describe the circuit of static differential relay for protection of two winding transformer. [8]