UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 7 Examination in Engineering: March 2021

Module Number: EE7213   **Module Name: Power System Protection**

[Three Hours]

[Answer **all questions**, each question carries 10 marks]

Q1. a) i) What is the basic objective of power system protection?

   ii) List and explain the essential qualities of a power system protection scheme.

   [5.0 Marks]

   b) i) Order following list of protection schemas from low selectivity to high selectivity with clear explanation.

   A. Directional overcurrent protection
   B. Non-directional overcurrent protection
   C. Transformer differential protection
   D. Distance protection

   ii) Transformer inrush currents during energization result in mal operation of transformer differential protection. Explain two approaches that can overcome this problem and how those approaches affect to the sensitivity of the protection scheme.

   [5.0 Marks]

Q2. a) i) What is the directional overcurrent protection relay? Explain one application of directional over current protection in power system protection.

   ii) Figure Q2a shows the construction and the phasor relationship between the input voltage (V) and the input current (I) of an induction type directional overcurrent protection relay. $\emptyset_v$ and $\emptyset_I$ are the magnetic flux produced by the input voltage and the input current respectively. τ is the maximum torque angle. Explain the working principle, the torque equation and the operational characteristic of the directional over current relay.

   [6.0 Marks]

   b) Non-directional overcurrent protection relay is used in high voltage side of a three-phase power transformer with specification of 1600 kVA, 11kV/0.415kV. Operating time equation of the protection relay is given below. Transformer high voltage side CT ratio is 125/1 A. Relay pick up

current is set to 1.2 times rated current of the transformer. The operating time of the relay at fault current of 2 times the pickup current is 1.003 seconds.

$$t_d = \frac{TMS \times 0.14}{\left(\frac{I}{I_{pickup}}\right)^{0.02} - 1}$$

i) Find the pickup current of the protection relay.

ii) Calculate the Time Multiplier Setting of the protection relay.

iii) Determine the operating time of the relay for a fault current of 300 A.

[4.0 Marks]

Q3. a) Explain the working principle of an impedance relay using a neat sketch, the torque equation, and the operational characteristic.

Universal torque equation is given by
$$T = K_1 I^2 + K_2 V^2 + K_3 VI \cos(\theta - \tau) + K_4$$

[5.0 Marks]

b) i) Explain stepped time – distance characteristics of three zone (I, II, III) protection of an impedance relay.

ii) Explain how to achieve 100% protection of transmission line with the above explained protection relay schema.

[5.0 Marks]

Q4. a) i) Name four protective devices used for conservator tank type power transformers.

ii) Explain the challenges of implementing a differential protection scheme for a transformer.

iii) With neat sketch, explain how a percentage differential relay overcomes above mentioned challenges.

[6.0 Marks]

b) 31.5 MVA, 132 kV/11 kV three phase transformer is protected by a percentage differential protection relay. Current transformer (CT) ratio on 132 kV side is 200/1 A and that on the 11 kV side is 2000/1 A. Transformer no load loss at rated current 10%, CT error 5% both side, Relay input error 4%, Tap changer position ± 12 x 1.5 %.

i) Calculate CT matching factor.

ii) Explain how to compensate CT ratio difference with CT matching factor at 75% of rated load.

iii) Draw 2 slope percentage differential relay characteristics, with all required values.

[4.0 Marks]

Q5. a) i) Briefly explain four causes of overheating of a motor.

ii) What is the difference between an overcurrent protection relay and a thermal overload relay?

iii) Describe the application and the importance of reverse power protection relay in generator protection.

[5.0 Marks]

b) i) Explain how an unbalance current causes overheating of a motor?

ii) Explain your recommendation for a time characteristic of a negative sequence overcurrent protection.
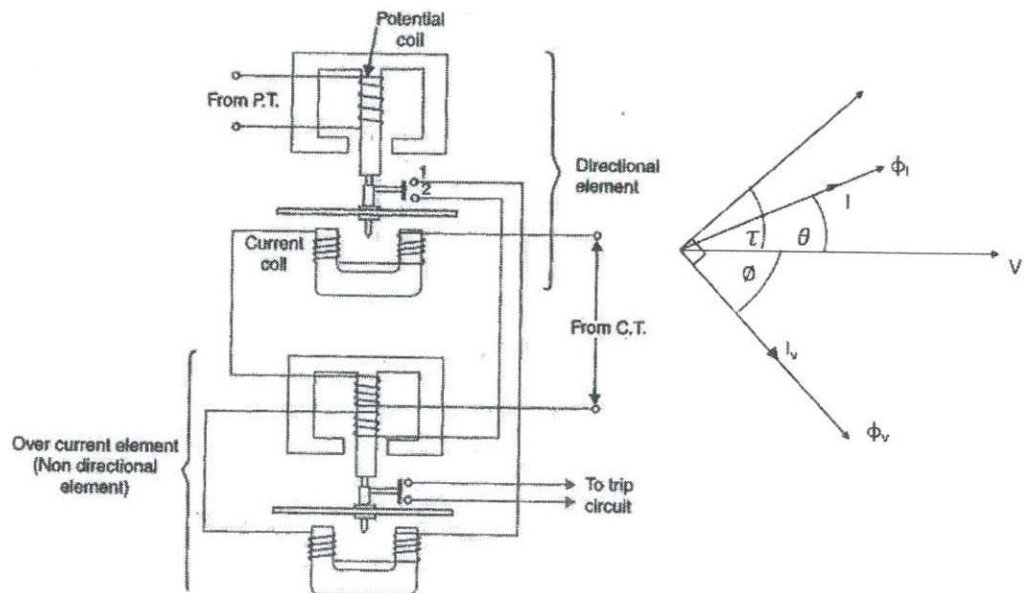
[5.0 Marks]

Figure Q2a