POWER SYSTEM – II
LAB MANUAL

(CODE : EE 692)

JIS COLLEGE OF ENGINEERING

(An Autonomous Institution)

Electrical Engineering Department

Kalyani, Nadia

POWER SYSTEM – II

CODE : EE 692

Contacts :3P

Credits : 2

1. Study on (i) on load Time Delay Relay (ii) off load Time Delay Relay

2. Polarity, Ratio and Magnatisation Characteristics Test of CT & PT

3. Testing on (i) Under Voltage Relay and (ii) Earth Fault Relay

4. Study on D C Load Flow

5. Study of A C Load Flow Using Gauss – Seidel Method

6. Study of A C Load Flow Using Newton Raphson Method

7. Study on Economic Load Dispatch

8. Study of Transformer Protection by Simulation

9. Study of Generator Protection by Simulation

10. Study of Motor Protection by Micon Relay

11. Study of Different Characteristics of Over Current Relay

Experiment No: 01

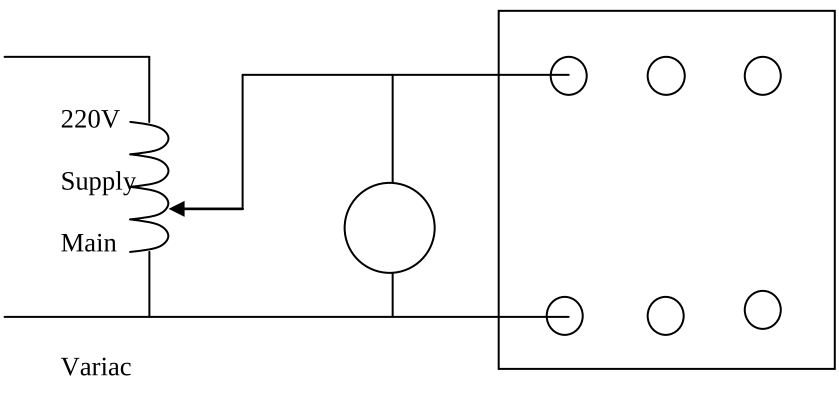
Title: Testing of Under Voltage Relay.

Objective: To study the operation of under voltage relay.

Theory:

Under voltage protection is provided for AC circuit, bus bars, motors, rectifiers, transformers etc. This type of relay is necessary for voltage control and reactive power control of network busses and load busses. Under voltage relay can have instantaneous characteristics (for armature type construction) or inverse characteristics (Induction, disc type construction) depending upon design.

The relay energized by voltage to be monitored via potential transformers. The operating voltage of the relay adjusted by proper tap setting and by proper selection of voltage ratio of potential transformers. Relays have multiple no of power free NO & NC contacts. When applied voltage across the relay more than the set point voltage relay become SET that is NO contacts become close and NC become open. When operating voltage less than set point voltage relay become RESET that is all auxiliary contacts back it is original state.



Relay Back Plane Connection

Instrument and Equipment Used

SL. No	Name of Apparatus	Quantity	Type/Specification	Maker`s Name

Procedure:

1. Measured Voltage is connected to terminal no 9 & 10. Two Auxiliary powers free NO contacts between 1 & 2 also between 2 & 3.
2. Relay energised directly from a variac. Connect the circuit as per given diagram.
3. Increase the supply voltage gradually.
4. Not down at what voltage relay becomes turn on that is indicator glow. This voltage known as PICK UP voltage.
5. Set the relay FLUG
6. Increase the supply Voltage up to 100 Volt. There from start to decrease the applied voltage. Not down at what voltage relay become turn OFF. Flag reset and indicator stop glowing. This voltage known as DROP OFF voltage.

Observation and Result:

PICK UP voltage

DROP OFF voltage

Note down all technical details of the relay

Conclusion / Discussion

Write your comments on the results obtained and discuss the discrepancy, if any.

EXPERIMENT NO: 02

TITLE:
Study of different characteristics of inverse over current relay.

OBJECTIVE:
To study the characteristics of inverse time over current and associated earth fault relay.

THEORY:
This type of relay works on the induction principle and initiates corrective measures when current in the circuit exceeds the predetermined value. The actuating source is a current in the circuit supplied to the relay from the secondary winding of a current transformer. These relay used on AC circuit only and can operate for fault flow in either direction.
It consists of a metallic (Aluminium) disc, which is free to rotate in between the poles of two electromagnets. The upper electromagnet has a primary and secondary winding. The primary is connected to the secondary of a CT to the line to be protected and is tapped as intervals. The tapping is connected to a plug setting bridge by which the number of active turns on the relay operating coil can be varied, there by giving the desired current setting. The secondary windings are energised by induction from primary and is connected in series with the winding on the lower electromagnet. The control torque provided by a control spring. The spindle of disc carries a moving contact can be adjusted to any value between 0^0 to 360^0. The adjusting this angle, the travel of the moving contact can be adjusted and hence the relay can be given any desire time setting. There is more common terminology of the relay.

Pick up current: It is the minimum current in the relay coil at which the relay starts to operate.

Current setting: It is often desirable to adjust the pick up current to any desire value. This is known as current setting and usually achieved by the use of tapping on the relay operating coil. The taps are brought out to a plug bridge in front face of the relay.

Pick up current = Rated secondary current of CT * current setting

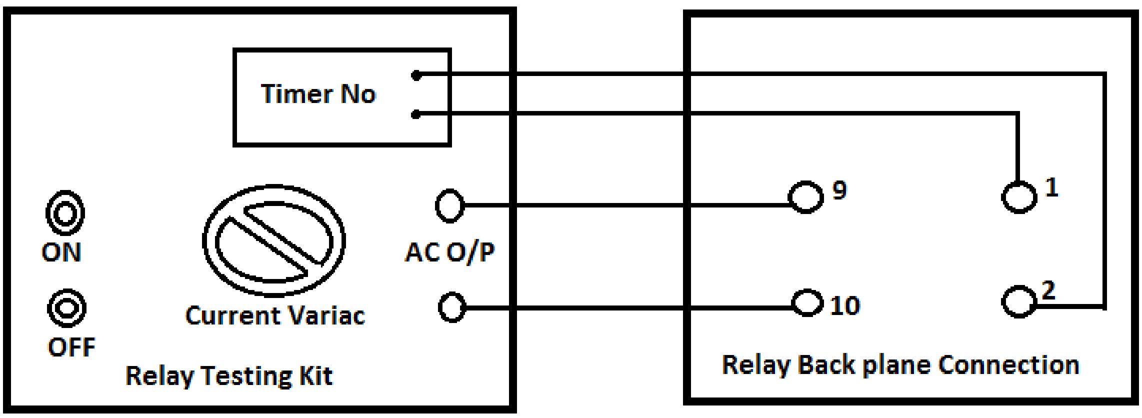
Plug setting multiplier (PSM): It is the ratio of fault current in relay coil to the pickup current.

PSM = Fault current in the relay coil / (Rated secondary current in CT * current setting)

Time setting multiplier (TSM): It is the ratio of actual operating time to time found from time vs PSM curve for a particular value of fault current.

Inverse time characteristics: In this type operating time is approximately inversely proportional to the magnitude of actuating current in relay. It never operate when the current in the relay less than pick up current.

CIRCUIT DIAGRAM:



INSTRUMENT AND EQUIPMENT USED:

Sl. No	Name of the Apparatus	Quantity	Type/Specification	Marker's Name
01				
02				
03				

PROCEDURE:

1) Connect the circuit as per circuit diagram.
2) Chose the proper current setting and time setting multiplier of the relay.
3) Increase the current variac up to a value more than the pick up current then switch off the current source without disturbing variac. Reset the timer.
4) Switch on the power of current source. After some time interval relay become off and current source become reset automatically.
5) Note down the current value and time value.
6) Repeat the experiment twice for same current value.
7) Change the input current and repeat the experiment for same current setting and time setting multiplier.
8) Draw the curve PSM vs Time and find out the error.

OBSERVATION AND RESULT:

Note down all technical details about the relay printed on the front panel.

No of Obser.	Relay current setting	Fault current	PSM	TSM	Time of interval	Actual given time	% Error
01							
02							
03							
04							
05							
06							
07							
08							
09							

CONCLUSION / DISCUSSION:

Write your comment on the result obtained and discuss the discrepancy, if any.

EXPERIMENT NO: 03

TITLE:

Study of Instantaneous earth fault relay.

OBJECTIVE:

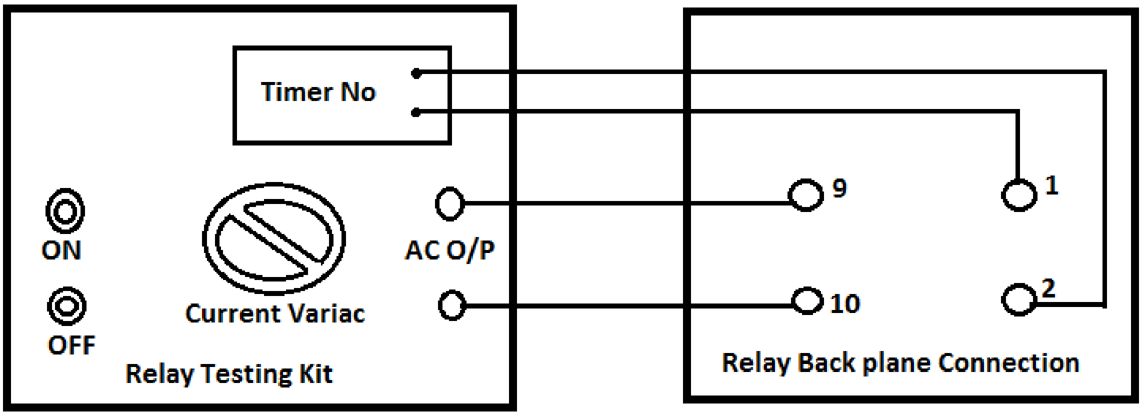
To study the characteristics and operation of instantaneous earth fault relay.

THEORY:

This is a solenoid type relay. It consists of a solenoid and a moving iron plunger arranged as shown under the normal operating condition, the current trough the relay coil is such that it holds the plunger by gravity or spring in the bottom position. On a occurrence of a fault, the current through the coil becomes more than the pick up value causing the plunger to be attracted to the solenoid. The upward movement of the plunger close the trip circuit. The minimum current at which the solenoid attracted is known as pickup current. Current setting usually achieved by the use of tapping on the relay operating coil. The taps are brought out to a plug bridge on the front panel of the relay. The plug bridge permits to alter the no of turn on the relay coil. Relay has multiple no of power from NO & NC contacts. The relay is energized by the secondary of CT. When the relay current more than the set point current, relay become on. NO contact become close and NC become open.

This type of relay is one in which no intentional time delay is provided. In this case the relay contacts are closed immediately after current in the relay coil exceeds the minimum calibrated value. Although there will be a short time interval between the instant of pickup and closing of relay contacts. Relay operating time less than 0.1 seconds.

CIRCUIT DIAGRAM:



INSTRUMENT & EQUIPMENT USED:

Sl. No	Name of the Apparatus	Quantity	Type/ Specification	Marker's Name
01				
02				
03				

PROCEDURE:

1) Connect the circuit as per circuit diagram.
2) From current variac output connect to relay terminal no 9 & 10 from relay terminal no 1 & 2 feedback to timer input terminals. Set the timer at NO mode.
3) Chose the proper current setting of the relay.
4) Increase the current variac up to a value more than the pickup current then switch off the current source without disturbing the variac. Reset the timer.
5) Switch on the power of current source again. Within a fraction of seconds relay become reset and current source become reset automatically.
6) Note down the current value and time value.
7) Repeat the experiment twice for same current value change the current setting and repeat the experiment again.
8) Find out the error.

OBSERVATION & RESULT:

No of observation	Relay current setting	Fault current	Time of interval
01			
02			
03			
04			
05			
06			
07			
08			

CONCLUSION / DISCUSSION:

Write your comments on the results obtained and discuss the discrepancy, if any.

EXPERIMENT NO: 04

TITLE:

Polarity, Ratio and magnetisation characteristics test of CT and PT.

OBJECTIVE:

Testing of Polarity, Ratio and magnetisation characteristics of current Transformer and Potential Transformer.

THEORY:

Current Transformer and potential Transformer are known as instrument transformer. In a high voltage and high current circuit direct measurement of voltage, current and other electrical parameter instrument transformer are used. PT is connected to the main bus of the associated power system, stepped down secondary voltage is measured by the instrument displayed actual high voltage after proper calibration. Primary of CT connected in series with the equipment whose current is to be measured and the secondary current measured by the instrument displayed actual high primary current after proper calibration. Using CT and PT we can electrically isolate the measuring devices from the main circuit and measuring device can be placed any far distance in control room.

In case of a PT primary voltage rating according to the high voltage circuit but secondary voltage rating is fixed to 110 V. In case of CT primary rating will be according to the high current in primary circuit but secondary current rating is fixed to either 1A or 5A.

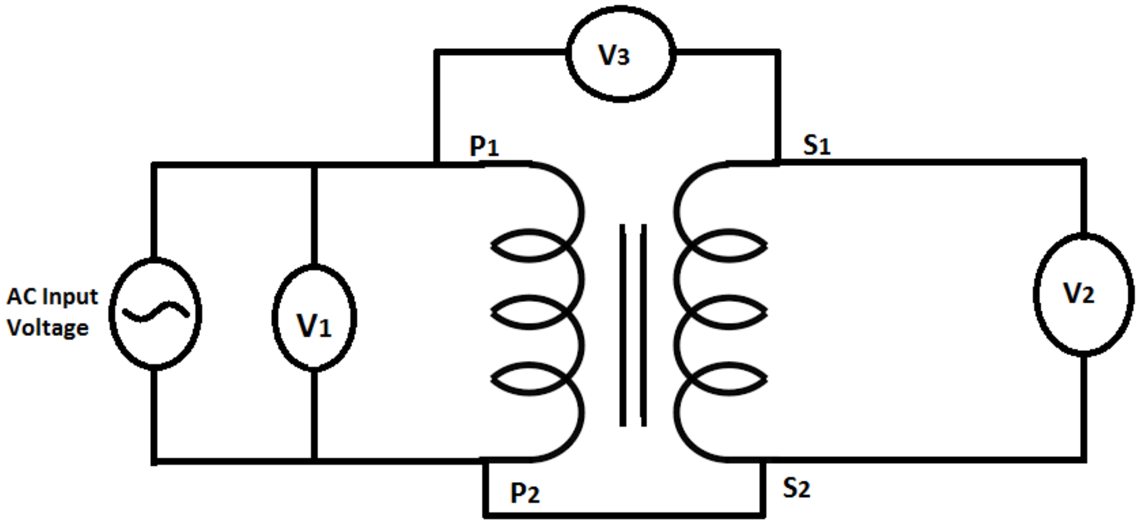
VA burden of CT and PT is being calculated from their voltage and current loading to the maximum polarities of transformer define the phase shift between two sides, which is either 0^0 or 180^0. There are two type of CT one is measuring CT and other is protection CT.

When a single CT output is fed to an ammeter or a PT output fed to a voltmeter there is no need to know the polarity of transformer. But when CT and PT connected in star or delta in case of three phase circuit they must be connected according to their polarity. Performing polarity test we can find out the symmetrical terminals between primary and secondary wingding of a CT and PT.

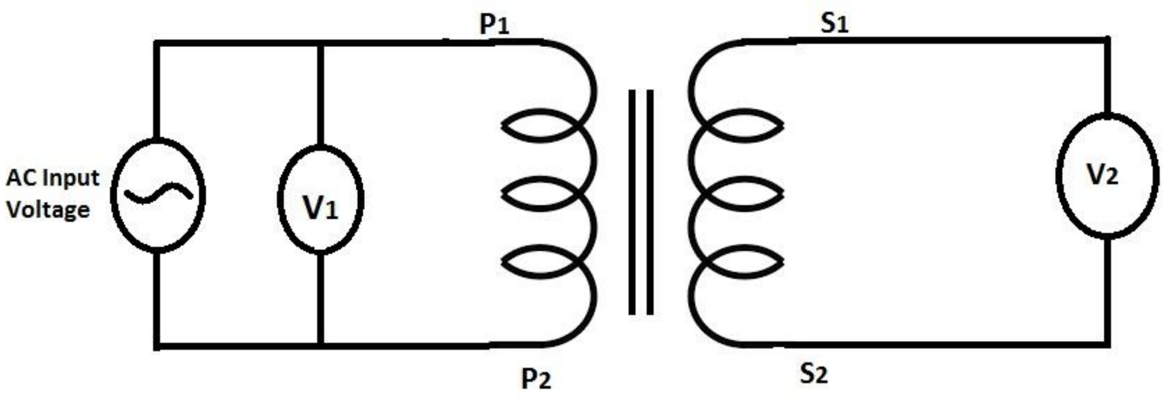
Using ratio test we can find out the voltage ratio for PT and current ratio for CT between primary and secondary at different point throughout its full operating range. Through this test we can also find out whether it is constant at all point or not.

Transformer core must not be saturated within its operating zone. If it saturated then due to change of input voltage or current in primary make no change in secondary that cause the error in measurement. We can determine its property from the data of ratio test. If the transformer ratio never changes between its full operating ranges means that core of the transformer is healthy condition.

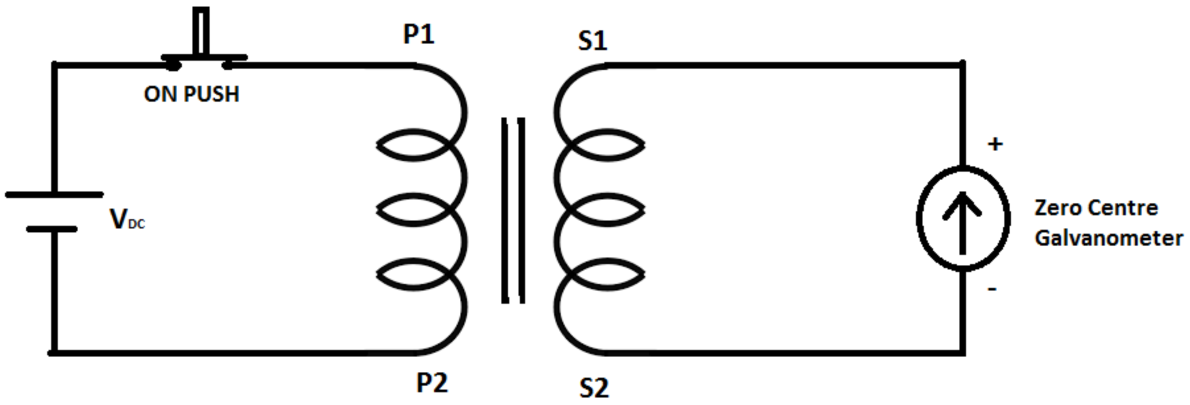
Circuit diagram for Polarity test of PT using AC supply:



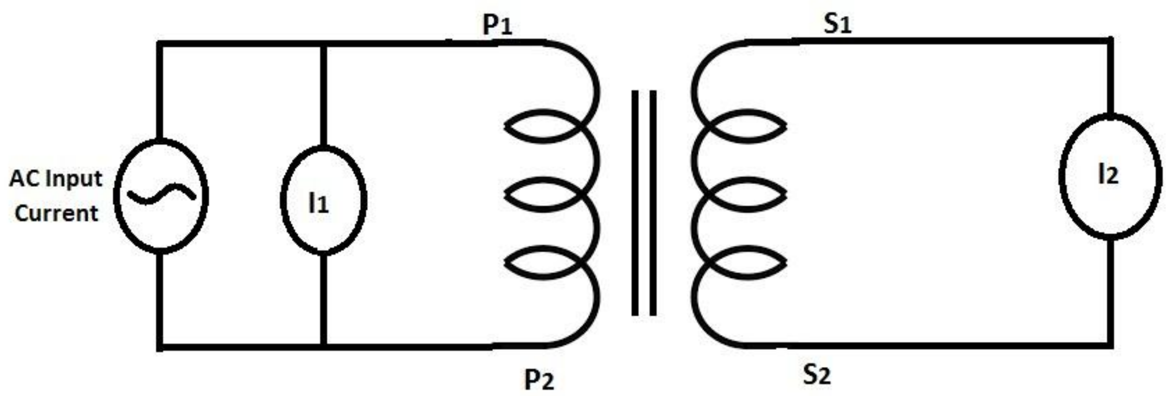
Circuit diagram of ratio test of PT using AC supply:



Circuit diagram for Polarity test of CT using DC supply:



Circuit diagram of ratio test of CT using AC supply:



INSTRUMENT AND EQUIPMENT USED:

Sl. No	Name of the Apparatus	Quantity	Type	Marker's Name
01				
02				
03				

PROCEDURE:

Polarity test of PT using AC supply:

1) Connect the circuit as per circuit diagram and marked the each terminals of primary and secondary wingding input voltage at suitable value. Read the input voltage (V_1) and output voltage (V_2).
2) If the voltmeter connected between primary and secondary reads the sum of voltages of ($V_1 + V_2$). Then P_1 and S_1 are opposite polarity.
3) If the voltmeter connected between primary and secondary reads the difference of voltages of ($V_1 – V_2$). Then P_1 and S_1 are same polarity.

Ratio test of PT:

1) Connect the circuit as per circuit diagram.
2) Connect the PT primary to the output of variable voltage source.
3) Increase the input voltage and take input and output voltage reading at least 10 point over its operating range.
4) Find out the transformation ratio. Also find error from the given ratio of the transformer.

Polarity test of CT using DC supply:

1) Connect the circuit as per circuit diagram and marked the each terminals of primary and secondary wingding.
2) Be sure the input voltage polarity to the input terminals and polarity of centre galvanometer connection in the output terminals.
3) Operate the push button for a fraction of time. Find the direction of deflection of the zero centre galvanometer.
4) If deflection is right hand side that means supply positive terminal and galvanometer positive terminal is same polarity. If deflection is left hand side that means supply positive terminal and galvanometer positive terminal is opposite polarity.
5) Repeat the whole experiments after reversing the source.

Ratio test of CT:

1) Connect the circuit as per circuit diagram.
2) Connect the CT primary to the output of variable current source.
3) Increase the input current and take input and output current reading at least 10 point over its operating range.
4) Find out the transformation ratio. Also find error from the given ratio of the transformer.
5) Be sure that at any condition CT secondary will not open during primary energies.

OBSERVATION AND RESULT:

Polarity test of PT:

Input voltage (V_1)	Output voltage(V_2)	Voltmeter between primary and secondary	Polarity according to marking

Ratio test of PT:

No of observation	Input voltage (V_1)	Output voltage (V_2)	Transformation Ratio (V_1 / V_2)
01			
02			
03			

Polarity test of CT:

Supply DC polarity to the primary terminal according to marking	Connected galvanometer to the secondary terminal marking	Direction of deflection	Polarity of terminals according to marking

Ratio test of CT:

No of observation	Input current (I_1)	Output current (I_2)	Transformation Ratio (I_1/ I_2)
01			
02			
03			

CONCLUSION / DISCUSSION:

Write your comments on the results obtained and discuss the discrepancy, if any.

QUESTIONS:

a. Why secondary of CT is not kept open?
b. What do you know about ratio error & phase angle error?

EXPERIMENT NO: 05

TITLE:

Run the Newton-Raphson load flow analysis program using ETAP (Electrical Transient Analyser Program) Power station.

OBJECTIVE:

To calculate the bus voltage, branch power factors, currents and power flows throughout the electrical system. [The program allows for swing, voltage regulated and unregulated power sources with multiple utility and generator connections].

THEORY:

Newton-Raphson Method

The Newton-Raphson Method formulates and solves iteratively the following load flow equation.

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} \begin{bmatrix} J_1 & J_3 \\ J_2 & J_4 \end{bmatrix} = \begin{bmatrix} \Delta \delta \\ \Delta V \end{bmatrix}$$

Where ΔP & ΔQ are specified bus real power and reactive power vectors, m is match vectors between specified value and calculated value respectively; ΔV and Δδ magnitude vectors and represents bus voltage angle in incremental form and J_1 through J_4 are called Jacobian matrices.

The Newton-Raphson Method possesses a unique quadric convergence characteristics. It usually has a very fast convergence speed compare to other load flow calculation methods. It also has the advantage that the convergence criteria are specified to ensure convergence for bus real power and reactive power mismatches. This criteria gives direct control of the accuracy you want to specify for the load flow solution. The convergence criteria for the Newton-Raphson method are typically set to 0.001MW & MVAR.

The Newton-Raphson Method is highly dependent on the bus voltage initial values. A careful solution of bus voltage initial values is strongly recommended. Before running load flow using the Newton-Raphson method, Power station makes a few Gauss-Seidel iteration to establish a set of sound initial values for the bus voltage.

The Newton-Raphson Method is recommended for use with any system as a first choice.

SOFTWARE USED:

ETAP power station 5.2

PROCEDURE:

1) Draw the circuit as per connection diagram.
2) Give input to all the elements.
3) Select Newton-Raphson method on study case tool bar.
4) Run the load flow program.
5) Now observe the result.
6) Take complete Report

RESULT:

CONCLUSION:

QUESTIONS:

a. If n is the no of buses and m is the no of PQ buses what will be the dimension of Jacobian Matrix?
b. What is FDLF method?
c. What are the advantages of FDLF method over N-R method?

EXPERIMENT NO: 06

TITLE:

Run the Accelerated Gauss-Seidel Method load flow analysis program using ETAP (Electrical Transient Analyser Program) Power station.

OBJECTIVE:

To calculate the bus voltage, branch power factors, currents and power flows throughout the electrical system. [The program allows for swing, voltage regulated and unregulated power sources with multiple utility and generator connections].

THEORY:

Accelerated Gauss-Seidel Method:

The Accelerated Gauss-Seidel Method formulates and solves iteratively the following load flow equation.

$[P + jQ] = [V^T][Y^*_{BUS}][V^*]$

Where ΔP & ΔQ are specified bus real power and reactive power vectors, ΔV is the bus voltage vector, and Y_{BUS} is the system admittance matrix.

The accelerated Gauss-Seidel method has relatively lower requirement of the bus initial voltage values compared to the Newton Raphson and the fast-decoupled method. Instead of using bus real power and reactive power mismatch as convergence criteria, the accelerated Gauss-Seidel method checks bus voltage magnitude tolerance between two consecutive iterations to control the solution precision. The typical value for bus voltage magnitude precision is set to 0.000001 pu.

The accelerated Gauss-Seidel method has slower convergence speed. When you apply appropriate acceleration factors, a significant increase the rate of convergence can be obtained. The range for the acceleration factor is between 1.2 typically set to 1.45.

SOFTWARE USED:

ETAP power station 5.2

PROCEDURE:

1. Draw the circuit as per connection diagram.
2. Give input to all the elements.
3. Select Accelerated Gauss-Seidel method on study case tool bar.
4. Run the load flow program.
5. Now observe the result.
6. Take complete Report

RESULT:

CONCLUSION:

QUESTIONS:

a. What is Acceleration factor?
b. Compare between the Gauss-Seidel load flow method and the Newton – Raphson Load flow method.