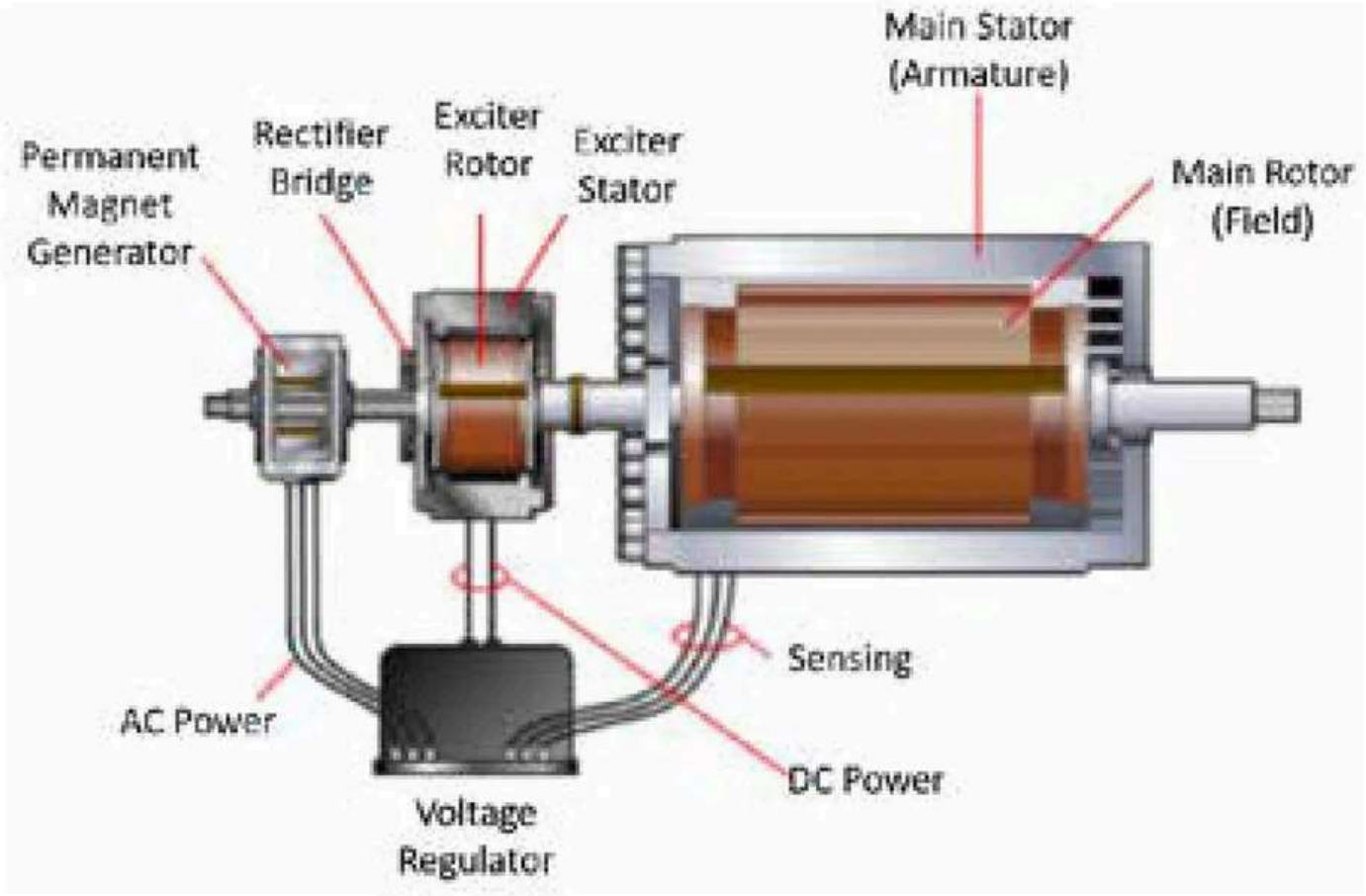
AUTODESK Instructables

Generator Rotor Earth Fault Protection

By SwapnilMore in WorkshopScience

Introduction: Generator Rotor Earth Fault Protection



The field circuit of a synchronous generator, comprising the winding, the exciter and the field circuit breaker, is a DC circuit which is not earthed. If the earth fault occurs, no fault current will flow due to lack of return path and not damage will be incurred. If the second earth fault takes place at separate point in the field, this constitutes the winding short circuit of the excitation circuit where part of the winding is by-passed, and current through the remaining portion may be increased.

The field current from the large machine can be high, causing serious damage to the rotor and exciter. If a large part of the field winding is short circuited, the flux may result in an attracting force which is strong on one pole and weak on the opposite pole. The result is an unbalanced force causing violent vibrations. This may lead to damage to bearings or even displacement of rotor which in turn may damage the stator.

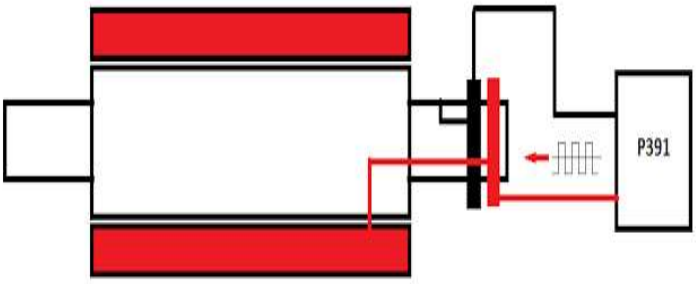
After the first earth fault, risk of second earth fault increases due to introduction of an earthed reference for voltage induced in the field by stator transients. These transients increase stress to earth at other points in the field winding.

In this blog post, we'll discuss about rotor earth fault protection as applied thorough MICOM P391 and P345 relay. Lets begin !

Step 1: Working

The rotor earth fault protection injects a DC voltage into the rotor circuit; the polarity of the voltage is reversed at low frequency (1Hz).

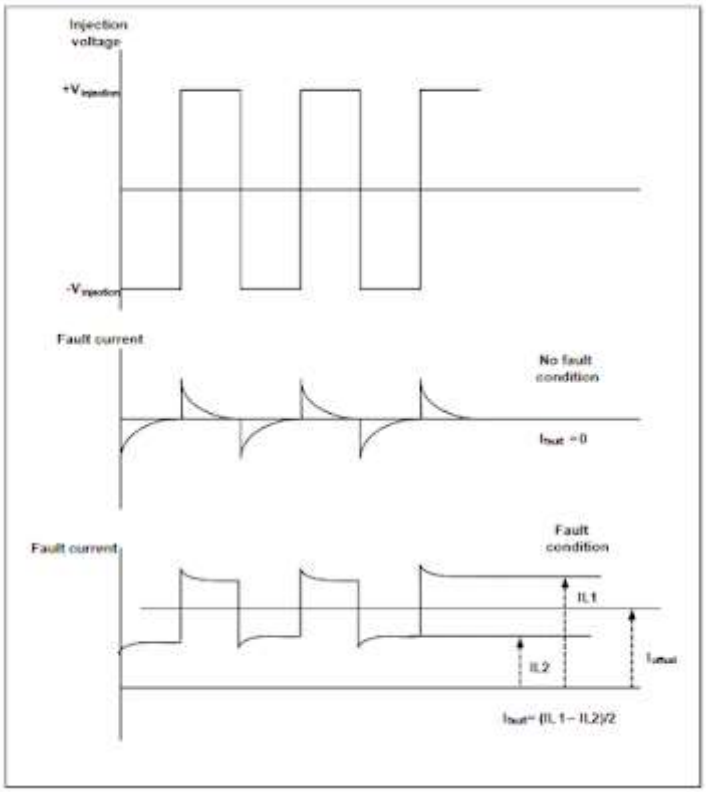
The voltage source is symmetrically coupled to the excitation circuit via high resistance resistors. It is also connected to the earthing brush of the rotor via a low resistance measuring shunt.



Every time the DC voltage is reversed in polarity, a charging current will flow due to the capacitance of the rotor windings to earth. Under no fault conditions, the charging current should be discharged to zero. If the measurements are made when the current reaches steady state, zero current should be measured indicating that the fault resistance is infinite.

When a rotor earth fault occurs, the steady state current will no longer be zero. The magnitude of fault current can be used to calculate the fault resistance. This arrangement is complicated by the fact that, depending on the position of the fault on the excitation winding, the excitation voltage will generate an offset, I offset, to the fault current produced.

Therefore, the measuring unit measures the steady state current for positive and negative reversal of the injection voltage; calculates the difference between the two and then takes the average. The resultant calculation is equal to the loop current through the equivalent circuit as shown. This eliminates the effect of the capacitance from the excitation windings.



Output of MICOM P391 output is 0 - 20mA which is fed to P345 Generator protection relay for Rotor Earth Fault.

The rotor earth fault protection in the P342/3/4/5 includes 2 stages of under resistance protection. The under resistance protection is designed as a two stage protection system, one alarm stage (64R R<1) and one trip stage (64R R<2), with each stage having a definite time delay setting. The injection frequency is selectable 0.25/0.5/1Hz via a jumper link in the P391.

Step 2: Calibration

Connection

Connect Decade resistance box across neutral grounding transformer primary. Make sure to insert isolator in series to disconnect the decade box since resistance values will change if it is in service for long duration due to heating at lower resistance values. Change in decade box resistance will introduce error in calibration. We can also add fix value resistance of 500 ohms or 1kOhms, 1Amp after isolator to restrict heating at lower resistance values.

Procedure

Note down all protection settings related to Rotor earth fault and also related measurements.

SN	PARAMETER	SETTING BEFORE CALIBRATION
1	INJECTION FREQ	
2	CL I/P SELECT	
3	64R R<1 ALARM	
4	64R R<1 ALM SET	
5	64R R<1 ALM DLY	
6	64R R<2 TRIP	
7	64R R<2 TRIP SET	
8	64S R<2 TRIP DLY	
9	R COMPENSATION	

SN	PARAMETER	READING
1	64R CL INPUT	
2	64R R FAULT	

There are three stages of calibration

1. Setting series resistance compensation
2. Fine tuning series resistance compensation at alarm and trip setting values
3. Checking operation of relays at various resistance values

Step 1

1. Keep isolator in open condition.
2. Reset R compensation value to 0.
3. Apply short at both slip ring and check '64S R Fault' in measurement. It should be 0 and if not, adjust '64R Compensation' to make measurement to read 0 ohm resistance. Remove the short after completion of compensation settings.

Step 2

1. Set resistance equal to trip value in decade box and close the isolator.

2. Check for measurement of '64R R Fault'. Adjust '64R R Compensation' to match the reading with applied fault resistance.
3. Repeat same process for alarm value.

Step 3

1. Insert various resistance values into circuit and check for correctness of the measurement.
2. if values are not matching, whole process need to be carried out again.

SN	INJECTED RESISTANCE	MEASURED RESISTANCE	REMARK
1	50		
2	49		
3	48		
4	47		
5	46		
6	45		
7	44		
8	43		
9	42		
10	41		

SN	INJECTED RESISTANCE	MEASURED RESISTANCE	REMARK
11	35		
12	25		
13	15		
14	10		
15	9		
16	8		
17	7		
18	6		
19	5		

Its always a good practice to check protection operation after completion of above procedure and everything is normalized by shorting both rotor slip rings to ensure protection is operational.

Now note down compensation parameters and measurements related to rotor earth fault protection.

SN	PARAMETER	SETTING AFTER CALIBRATION
1	R COMPENSATION	

SN	PARAMETER	READING AFTER CALIBRATION
1	64R CL INPUT	
2	64R R FAULT	

Rotor Earth fault calibration is simple compared to 100% Stator Earth fault since Angle Compensation factor is not applied here.