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Setup of an Arduino Based GIC Monitoring System And Study of GIC Variation at Ground Level

[1]Boyanapalli Bharath Kumar, [2]Diptanu Dey, [3]Sanjib Das, [4]Dr. Priyanath Das
National Institute of Technology, Agartala

***Abstract*:-- This paper deals with the setup of Arduino based monitoring system. In this paper, we calculated the amount of Geomagnetically Induced currents (GIC) in the power lines during normal conditions and during recent G1-class geomagnetic storm conditionsoccurred on November 2016. The selected site for this measurement was NIT Agartala Substation located in West Tripura, India. GIC will be induced due to the change in the magnetic field of the earth because of the geomagnetic disturbances (GMD) caused due to the solar flares. We calculated this change in the earth's magnetic field during the normal condition and during the recent magnetic storm condition. For this calculation we used a small magnetic field sensing chip called HMC5883L. This integrated chip (IC) senses the changes in the magnetic field. Since this IC is a 3-Axis chip it gives the value of magnetic field in X, Y, Z directions. We interfaced this chip with Arduino UNO and a program was implemented to make this chip sense the magnetic field variation. The readings are noted at two different points, i.e. One point was at under power lines and another was at a distance from the power lines. The readings were taken both at normal conditions and during the storm conditions. During the storm conditions the geomagnetic field was increased upto 360 uT under the power lines compare with the measured value under the power lines during the normal conditions.The difference in the magnetic field infers the GIC induced in the power lines. In this paper, we provided the setup of an Arduino based magnetic field measurement system and the measured range of GIC in the power lines.**

***Index Terms*— Arduino setup, GIC monitoring, GIC variation, Ground level**

I. INTRODUCTION

The sun propagates solar flares and these flares causes the changes in the magnitude of earths magnetic field with respect to the time. This change in the magnetic field induces an amount of current in the power lines which may cause a severe threat to the power system. This induced current in the power lines is called GIC. So we need to calculate the amount of GIC induced in the power lines, for this we need to calculate the variation of geo magnetic field because of the GMD [1].

The GIC causes severe threat to many technological systems like gas pipelines, Tele communications lines, railway lines, power systems etc. The impact of GIC was explained by many incidents [2]. The impact of GIC was shown in the figure 1.

II. MEASUREMENT OF MAGNETIC FIELD INDUCED DUE TO GMD

GIC in the power lines is induced due to the variation of the geomagnetic field because of GMD.So to estimate the amount of GIC in the power lines we need to calculate the variation of the magnetic field of the earth.To measure this we used an IC HMC5883L interfaced with the Arduino UNO and a program has been implemented to make the sensor to sense the variation in magnetic field and gives its magnitude. The setup is shown in the figure 2. The readings were taken in such a way that, under normal conditions the data was recorded at two different points, one was under the power lines which measures the magnetic field due to GMD and Geomagnetic field. The other was at a distance away from the power lines where the only geomagnetic field was measured. The difference of the both will give the magnetic field induced only because of GMD. This magnetic field infers the amount of GIC flowing in the power lines.Similarly, the same procedure was repeated during the recent magnetic storm conditions and the variation in the magnetic field was observed during this period.

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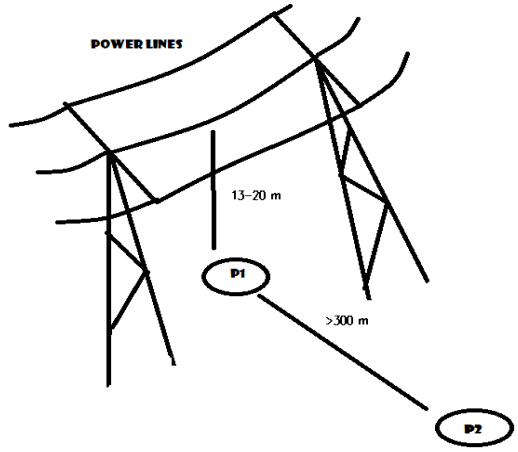

Figure 3. Setup for magnetic field measurement

The variation of the magnetic field during the normal and during the recent magnetic storm conditions was shown in the figure 3 and figure 4.

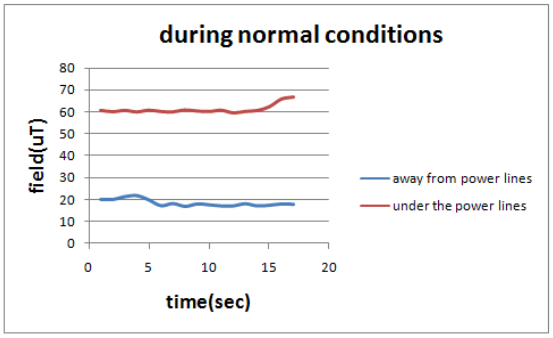

Figure 3. Variation of magnetic field during normal conditions.

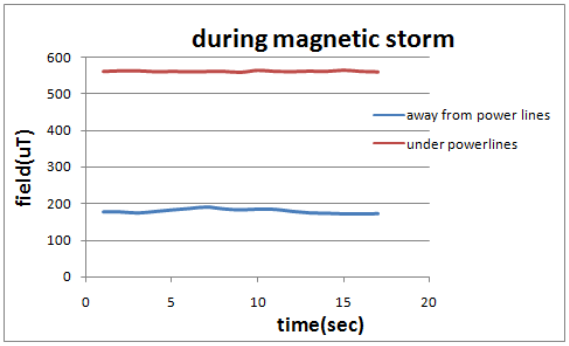

Figure 4. Variation of magnetic field during storm conditions

III. CALCULATION OF GIC

After getting the magnetic field induced due the GMD. The GIC was calculated from the formulae used below. The induced GIC due to the variation of geomagnetic field was calculated during the normal conditions and during the recent magnetic storm. The calculation is done in the following way, the NIT Agartala substation data were taken, the power lines used are All Aluminium Conductors (AAC) the resistance of the power lines used in the transmission of power was 0.915Ω/ KM, nominal area of the power lines is 150 mm2 and the length of the power lines was considered 100 KM i.e. From the Tripura electricity board to NIT Agartala substation. The important formulae used in calculation are given below.

$$\varepsilon = \frac{d\Phi}{dt}(\text{Volts}) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where ε= EMF induced in power lines in volts

$$\Phi = B.\ A \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where B = Magnetic Field in micro tesla and
A = Area of the power line in mm2

The magnetic field varies with respect to time and the area of the conductor is constant. By using the formulae 1 and 2 we calculated the EMF induced in power lines. After calculating the EMF from the substation data by taking the total resistance of the power line the current induced in the power line was calculated by using the formula below [3].

$$\varepsilon = IR \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

The GIC was calculated under the normal conditions and during the recent magnetic storm and its magnitude variation is shown in figure 5.

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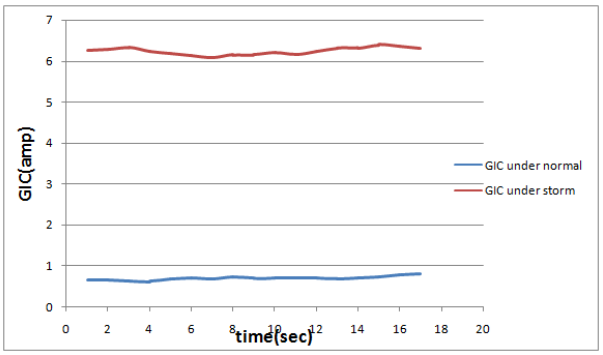

Figure 5. The magnitude of GIC (Amperes) in the power lines during normal and during magnetic storm conditions.

IV. RESULTS AND CONCLUSION

In this paper we provided the setup of an Arduino based monitoring required to measure the variation of the geomagnetic field during the normal conditions and during the recent magnetic storm conditions and the variation was shown in the figures 3 and 4 respectively. In this method we used an IC HMC5883L magnetic sensor interfaced with Arduino. A program has been implemented to make the sensor to sense the variation in magnetic field. In this paper, we calculated the amount of current induced i.e GIC in the power lines during the normal conditions and during the recent magnetic storm conditions which occurred in November 2016. By calculating the GIC during normal and storm conditions, we can conclude that during the storm conditions the GIC flowing in the power lines was increased compared with the normal conditions. This will be a severe threat to the power systems and various other technological systems and this should be mitigated.

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