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# Current Measurement and Monitoring using Hall Effect Concept

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***Abstract:***
***In this paper, we developed a new approach to measure the electrical parameters using non-contactable hall sensors and wireless communication measurement. The data of the measured parameters is displayed on a LCD display and also communicated to the registered mobile number using the GSM module. As we know that hall sensor detects the current flowing in a conductor without opening the working device circuit. The hall sensor produces a voltage signal proportional to the current in the conductor; this voltage signal is transferred to a programmed Microcontroller, where the analog voltage signal is modified into digital signal. This digital signal holds the measured current data, which is transferred to the LCD screen to display the current values and communicated to the registered mobile through GSM module. The above hypothesis is confirmed by theoretical and practical analysis, where the theoretical analysis is simulated using the PROTEUS and AURDINO software's.***

***These results show the electrical parameters of the equipment is displayed on the LCD screen and also communicated to mobile through GSM module. This paper presents effective and accurate non-contactable, wireless measurements.***

***Keywords - Hall Current Sensor, GSM Module, Microcontroller , LCD Display.***

## Introduction

At present scenario, under ON-Load condition of electrical machines like Transformers, Motors, Generators and other electrical equipment, there is no non-contactable, wireless instrumentation particularly for the measurement of current. And, it is very difficult to measure electrical parameters of the equipment in remote areas and distant areas. If we overcome these problems, we can improve the efficiency; conditional behavior of the equipment and the chances of faults reduction. Based on present day instrumentation, there is a need of an instrument to measure the currents in equipments like transformers, generators…, which is non-contactable and can measure a wide range of currents. To construct this instrument, we made use of linear hall current sensor, which can sense currents up to 30A without a direct contact to the current carrying conductor.

The hall sensor senses the current in the conductor and gives an output voltage proportional to the current in the conductor. This analog voltage signal is connected to a programmed Microcontroller, where the analog voltage signal is converted into a digital signal which holds the data of the measured current value. This digital signal is then transferred to Liquid Crystal Display screen to display the measured values and parallelly the digital signal is transferred to a GSM module, which sends a message to the registered mobile.

We set the GSM to send the measured values in certain time span (i.e.) hourly by programming to do so. And also, we program the Microcontroller in such a way that whenever over-current condition or under-current condition arises, GSM module automatically sends an alert message to the registered mobile.

## Literature Survey

From the beginnings of electrical engineering the quantification of the basic electrical units was a

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requirement for the work of physicists and engineers as well as the basis or the commerce with electrical energy. For the engineers, besides the electromagnetic field quantities, most notably the integral basic electric units, voltage and current, are of interest.

At first, it was the physical effects directly associated to the moving charge, like the force action of the magnetic field generated by a conductor, Joule's heat or the dissociating action of a current passing through a conductive liquid. Therefore, the first measuring instruments combined measurement transducer and display to an inseparable unit.

Electrical current sensors are well known and find a wide range of applications to the electronics industry [1]. There are a lot of current sensors such as current transformers, shunt resistors and Hall Effect current sensors, etc. [2-7]. Among these current sensors, Hall Effect current sensors have more advantages in good linearity, wide measuring range, high isolation between input and output, relative high accuracy, diverse sensor configurations and applications [5,6,7].

Before 1930, the development of instruments to measure small magnetic fields, the so-called fluxgate magnetometers, had begun, although the Hall-effect was described much earlier, in 1879. But it was not until the 1950s when semiconductors with Hall constants large enough were available so that practical magnetometers could be built. Also current transducers for large currents came up using Hall cells. In the first transducers the output voltage of a Hall cell in an air-gap was taken directly as a measure for an electric current flowing through the aperture of the core, later a compensation winding was added to achieve smaller errors. The measuring devices built at the end of the 1950s for aluminum plants reached errors smaller than 0.1%, which was sufficient for industrial purposes

Federal institutes responsible for the reproduction of basic units had much higher requirements for the measuring devices for calibration purposes: The institutes that contributed significantly to the development of current metrology are the Physikalisch - Technische Bundesanstalt (PTB) in Brunswick, Germany, the National Bureau of Standards (NBS) in the USA and the National Research Council (NRC) in Canada. It was here were in the 1960s the current comparator was developed, a sophisticated transducer designed to compare AC and DC currents with uncertainties below one ppm up to the audio frequency range.

In parallel with the evolution of the inductive current transducers, measuring shunts were improved. Constructions (co-axial shunts, disk shunts) were found which suppress any inductive voltage and can be used up to the GHz range where eddy currents effects can influence the measurement. Other physical effects used for the indirect) measurement of electrical currents are the Faraday effect (rotation of the polarization plane of a light beam by a magnetic field), nuclear magnetic resonance (NMR), the quantum Hall effect, magneto-resistance (anisotropic - AMR, giant - GMR, tunneling - TMR) and magneto-impedance. [8].

## Proposed Methodology

The proposed system consists of an Atmega32, which does all the function according to program interfaced. The hall current sensor is powered by an external supply and based on the hall effect principle it senses the current in the conductor and gives that information to the Atmega32,It provides an output to the LCD display and GSM module, which act accordingly.

The hall current sensor is connected to the conductor without any physical contact. This non-contact ability of the hall current sensor differentiates it from other current sensors. The Arduino is programmed in such a way that it modifies the analog signal from the hall sensor into a digital signal which holds the data of the measured current values. This digital signal is then provided to the LCD display to show the measurements instantaneously. The measured values are simultaneously provided to the GSM module which sends a message to the registered

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mobile containing the data in a specified time interval (i.e.) hourly, and an alert message is sent to the registered mobile whenever an over-current condition or under-current situation occurs.

Block diagram of the proposed system is shown in the figure 1. In this proposed system we made use of different components and each component is explained below. In this, Main components are GSM module, Atmega32A, LCD display, Hall sensors. Input data is detected from Hall sensors and transfer the received data to Atmega32, from here onwards it converts analog to digital to communicate to LCD, and registered mobile through GSM. Here ,to do all those things with accuracy, we are programmed the Atmega32.

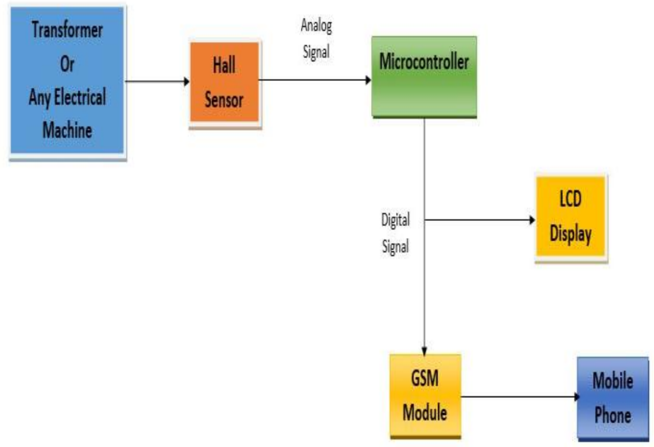


Fig.1 Proposed system Block diagram

### Hall current sensor

A Hall Effect current sensor allows non-contact detection of direct and alternating currents, using a hall element, a magnet-electric converting element. This minimizes the power loss of the target current circuit and has a simple structure with high reliability.

These hall sensors are based on Hall Effect principle which states that when a current carrying conductor is placed in in a magnetic field, a voltage will be generated perpendicular to direction of field and the flow of current.

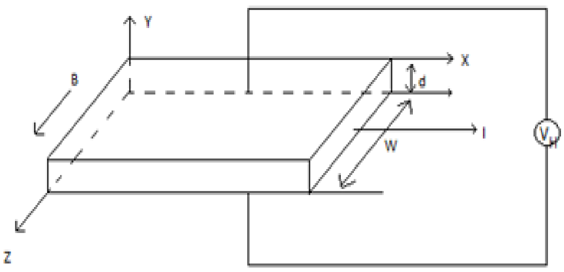


Fig.2 Hall Effect

The above figure shows a conductor placed in a magnetic field (B) along the Z-axis. The current (I) flows through it along the X-axis. Then the hall voltage ($V_H$) is developed along the Y-axis with electric field intensity ($E_H$).

At equilibrium,
Force due to hall voltage on charge carriers = force due to magnetic field.

$$F_E = F_B$$

$$qE_H = Bqv$$

Where, $q = Magnitude\ of\ Current$

$$v = Drift\ Velocity$$

$$\therefore E_H = \frac{V_H}{d}$$

$$\frac{V_H}{d} = Bv \qquad (1)$$

And current in the conductor is given by,

$$I = \frac{Q}{t}$$

$$I = \frac{n.e.A.d}{t}$$

Where, $n.e = Charge\ Density$

$$A = Area\ of\ cross\ section\ of\ the\ Conductor$$

$$I = n.e.A.v$$

$$v = \frac{I}{n.e.A} \qquad (2)$$

From Eq (1) and Eq (2)

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$$\frac{V_H}{d} = \frac{B.I}{n.e.A}$$

$$V_H = \frac{B.I.d}{n.e.d.w}$$

$$V_H = \frac{B.I}{n.e.w}$$

$$V_H \ \alpha \ I \qquad (3)$$

Eq (3) states that the Hall voltage produced is directly proportional to the current in the conductor.

For high ampere ratings we use split-core hall sensors and for low ampere ratings we can use linear hall sensors. they both work on same hall effect principle.

## MICROCONTROLLER:

MC is a small computer on a single integrated circuit. In modern terminology, it is similar to, but less sophisticated than, a system on a chip or SoC; an SoC may include a microcontroller as one of its components. A microcontroller contains one or more CPUs (processor cores) along with memory and programmable input/output peripherals. Program memory in the form of ferroelectric RAM, NOR flash or OTP ROM is also often included on chip, as well as a small amount of RAM. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications consisting of various discrete chips

## GSM Module:

A GSM (Global System for Mobile) module is a device, which can either a mobile phone or a modem device which can be used to make a computer, or any other processor communicate over a network. A GSM modem requires a SIM (Subscriber Identity Module) card to be operated and operates over a network range subscribed by the network operator. It can be connected to a computer through a serial or a USB or a Bluetooth connection.

GSM is SIM900A[9] Quad-Band GSM/GPRS device, works on frequencies 850MHz, 900MHz. it is very compact and easy to use as plug in GSM modem. The Modem is designed with 3V and 5V interfacing circuitry, which allows User to directly interface with microcontrollers (PIC, AVR, Arduino, 8051, etc.).

## Liquid Crystal Display (LCD)

An LCD is an electronic display module which uses liquid crystal to produce a visible image. The 16*2 LCD [10] display is a very basic module commonly used in DIYs and circuits. The 16*2 translates and display 16 characters per line in 2 such lines. In this LCD each character is displayed in 5*7 pixel matrix.

These modules are preferred over seven segments and other multi-segment LEDs. The reason being: LCDs are economical, easily programmable, have no limitations of displaying special and custom characters.

## Simulation Analysis

The microcontroller program is compiled by using the Arduino C compiler. We made use of PROTEUS CAD software to design the proposed system virtually. Hall sensors have been replaced by voltage sources, as it is impossible to interface Hall sensors in a simulation circuit. To reduce the clumsiness of the circuit the connections are made using probes. The Arduino program's .hex file is dumped into the Arduino 328 panel.

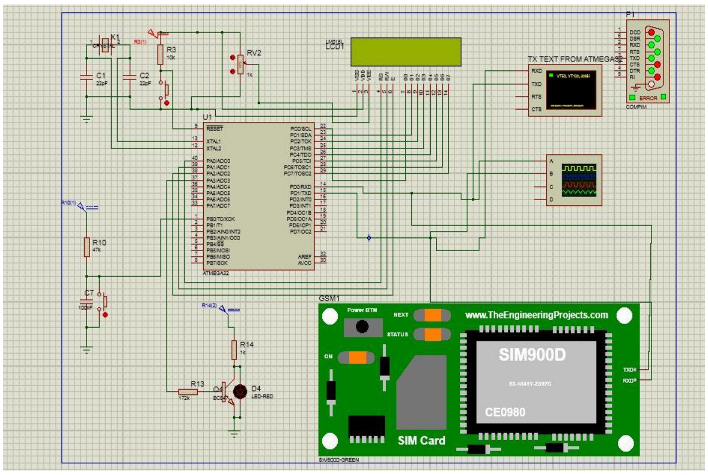


Fig.3 Simulation Diagram

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In this we have used voltage sources instead of hall sensors, as the output of hall sensors is hall voltage. To the corresponding hall voltages, the currents are displayed in the LCD screen and transferred to the registered mobile through GSM module. Here we have used SIM 900D GSM module.

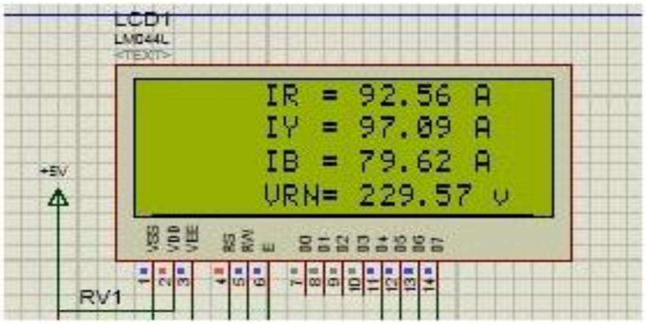


Fig.4 Simulation LCD Results

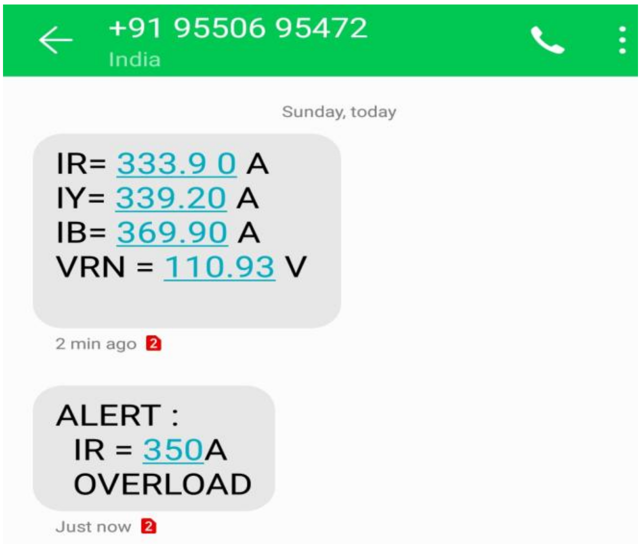


Fig.5 Messages received to registered mobile

## Hardware Implementation

The basic connection diagram of the proposed system is shown below. Based on this circuit the hardware is built around the Atmega32. External supply is given to the Microcontroller, Hall sensors and GSM module. The LCD display is powered through 5V source.

The maximum voltage that should be given to a Microcontroller analog pin is 12V, that's why we have chosen the hall sensors with a output ratiometric voltage of 4V for 500A. Whenever a voltage signal is detected the Arduino produces a digital signal corresponding to that voltage value. This signal is sent to LCD to display the current values and to the registered mobile through GSM module.

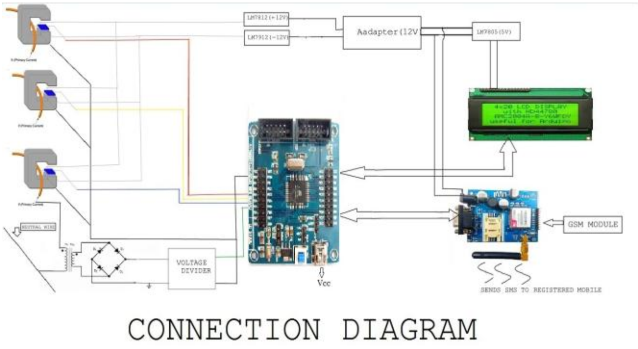


Fig.6 Basic Connection Diagram

In order to make the connections between the Atmega32, GSM module, LCD screen [11-13], we have used the bread-board and male-male jumpers and male-female jumpers.

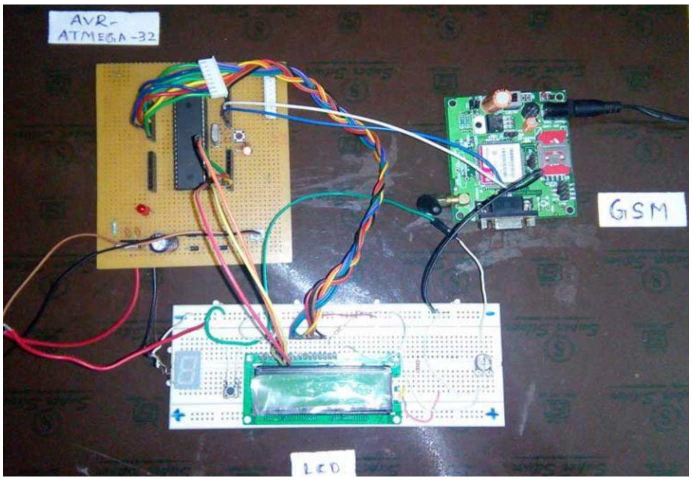


Fig.7 Hardware Setup

## Conclusion

The above proposed system for measuring high currents using hall current sensors, Arduino and GSM is advantageous as we can take current measurements without opening the existing circuit and the non-contactable hall current sensors reduces the probability of human errors and human inference.

The proposed system helps in taking current measurements from remote locations, helps in hourly data acquisition, and alerts the officials when an over-current or under-current condition occurs. This will help in improving the life span of the electrical equipment and it helps in reducing the man's effort in taking current readings.

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