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Smart Electric Sensing in Infrastructure

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Abstract: ***Smart homes utilize advanced systems to bring comfort and convenience to our living experiences. Most of the current frameworks are now trying to move towards automation such as smart homes, smart warehouses. This paper focuses on monitoring the wiring system of modern infrastructure as it is very important while moving into advanced systems. In order to reduce the labour involved in replacement of wires from the main board when fault occurs due to overload, short-circuit, arcing, equipment failure. we have provided a model called SESI, Smart Electric Sensing in Infrastructure, which uses the transistors and the Arduino to find the faults in the electric system. Although, many measures have been taken in smart homes to conserve electricity, there is no means to monitor them. Monitoring them would help us to conserve it more efficiently and also reduces the risk of fire accident***

Keywords: Real-time monitoring, short circuit, arcing, overloading.

I. INTRODUCTION

It is important to monitor the health of the wiring system since fluctuation of current, wear and tear, the damages caused by the appliances can cause damage to the wire paving way for fire accidents [1]. One of the greatest problems in infrastructure is that it needs effort to detect the fault at its place. Large scale industries also demand the need for a monitoring system to identify and quickly resolve problems to prevent electrical shutdown. It will be very useful if a device is used for real time monitoring of the wiring system to keep an eye on the functioning of the device.

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An important facet of a smart building is to protect the lightning system, which prevents damages caused by accidental fires. Overload occurs when there is excess supply of current in a point leading to damaged cables and sockets [2]. It is necessary to focus on incorporating a method to monitor the wires without the manual process.

In order to establish the above process, the blooming technology Internet of things plays a vital role. The Internet of Things deal with computational power, mechanical and digital machines which are provided with unique identifiers. It provides the capability to send data over a network without human intervention [3].

It is the developing technology in which a network of physical objects that uses an IP address for internet connectivity. It facilitates the communication between the internet-enabled systems and devices [4]. Data have been interchanged automatically between devices without the need of any human in real time. The IoT is the capability to transform ordinary products such as cars, buildings, and machines into smart, connected and intelligent objects that can interact with people, applications and each other.

An enterprise must have a system which will networks in a very secure manner [5]. It should also have a system to store and analyze the data and turn into useful information develop valuable data and transfer those data across multiple.

The approach in which various objects are equipped with processors, actuators and sensors which will be used to communicate properly is known as Internet of Things [6]. We use these capabilities to query the state of the object and to change its state if possible. The Internet of Things has many devices and appliances connected to each other via a network and refers to a new kind of world. They collectively achieve complex tasks that require a high degree of intelligence.

The IoT devices are provided with actuators, transceivers, processors and embedded sensors which enhances the interconnection and intelligence of the IoT device. Internet of Things is a collection of various technologies.

II. LITERATURE SURVEY

Bryan Steadman, Floyd Berghout, Nathan Olsen, Brent Sorensen, “Intermittent Fault Detection and Isolation System”, September 2008[7] The electronic boxes in aircraft often come across a maintenance challenge.

They malfunction during flight in the aircraft, but test good when it is diagnosed in ground. During ground test, they show a "No Fault Found" condition, which does not mean that the electronic box may work well during the actual flight. There may be intermittent faults that occur normally due to (momentary opens such as) cracked solder joints or corroded contacts.

These cannot be repaired because these problems cannot be found during the test. The reason why conventional test equipment fails is because the circuits are tested one at a time. The fault may not have occurred during the time of testing. Unless the intermittent fault occurs during testing, it is missed. Also, the box under test is not exposed to the temperature and stress that occurs in the operational environment and is done at room temperature. Over $13,000,000 cost is incurred annually for the testing and maintenance of the electronic boxes in aircraft.

Although the cost of maintenance is high, it does not find the intermittent faults in the electronic boxes. Hence this paper describes a tester that was designed to detect and isolate the intermittent circuits in an electronic box called Intermittent Fault Detection and Isolation System (IFDIS). The intermittent fault detection system consists of a Thermal Chamber, Shake Table, Intermittent Fault Detector. The Intermittent Fault Detector is a neural network analog instrument. It monitors the continuity of all the circuit paths and detects even a minute discontinuity in the circuit and records it. The chamber and shake table are used to provide a simulation of the environment in which the electronic box will be in use. A simulation of the operational environment enhances the probability that the intermittent faults will be detected. The temperature and vibration are also adjusted according to the operational environment. The fault detector, shake table and chamber are computer controlled. A test history is recorded along with all intermittent faults detected.

A.Laib, M.Melit, B.Nekhoul, K.Kerroum and K.Elkhamilichi Drissi, "Soft Fault Identification in Electrical Network using Time Domaine Reflectometry and Adaptive Neuro-Fuzzy Inference System", October 2017[8]

The modern electric systems comprise of the networks of wiring like industrial machinery, nuclear plants, transportation units, where the transportation of information is important for their efficient functioning.

For these to be efficient, there should be a system that should diagnose the wire in order to detect and locate electric faults.

There are two types of faults that occur in the electric system. They are the hard faults and soft faults. Hard faults include short circuiting, open circuits, etc., whereas soft faults include frays and chafes i.e., wear and tear of the wire.

Time Domain Reflectometry (TDR) is a method in which the signal is sent to the network and the deflections are recorded and the fault is found. This method is efficient for finding the hard fault. To make the TDR method more efficient and to work for detecting the soft faults, the Adaptive Neuro-Fuzzy Interference System (ANFIS) includes the method of Neural Networks for training the datasets and the Fuzzy Logic to determine whether the fault is present or not. Fuzzy logic is a system in which the statements of truth are formed and according to it the results are produced.

Here, the signals that are produced to the network are divided based upon the time appearance and magnitude. Using ANFIS, the time appearance gives the position of the fault and the magnitude gives the resistance that it has offered. With this data, the accurate location and the type of fault can be found. This method gives us the exact position where the soft fault has occurred and the exact resistance values of the fault which defines the state of electrical networks in real time.

Seung Jin Chang and Jin Bae Park, "Wire Mismatch Detection Using Convolutional Neural Network and Fault Localization Based on Time-Frequency Domain Reflectometry", 2008[9]

This paper briefs the method of fault detection on vehicle wiring system and it uses various methods for its analysis. In order to locate the termination of a target wire, a Gaussian-enveloped linear chip signal was selected using which the general parameters for finding the wire is found using TFCC process. After all the experiments the target parameters were set as 60MHz for center frequency,110MHz for bandwidth and 40ns for time duration.

The difference between the impedance discontinuities distance and the stored wire distance are calculated and if it exceeds the localization threshold value then the wire is considered to be in a faulty condition. If suppose the wire is found to be without faults then they are used for finding normalization using the CNN. The signal from the faulty wire is restored in order to find the accurate fault location. The incident signal is passed through the defective wire and the reflected signal obtained from this wire is used to distinguish among the various wires as red, yellow, blue or black using the pre-trained CNN model with 3,600 labelled images.

Through this normalization process each image matrix was transformed into new matrix and the Gaussian noise was added to the acquired signal to measure the influence if noise in the image. The information about the characteristics of the wire is stored in the filter bank. In advance and comparing the distance derived using the TFCC and the length stored in the filter bank, if any deviation in wire is present then there is defect in the target wire.

The experimental samples have an error rate classification with which the defect is analyzed and the location is also found using the wire fault localization method.

Polyakov D.A., Pugach V.N., Nikitin K.I., "Power Transmission Lines Monitoring System", 2018[10]

The main problem in the power transmission lines is the detecting of faults due to insulation breakdown and flashover. There are variety of techniques that are followed to find the transmission line insulation tests but the question of reliability is considered as one of the urgent issues to be considered.

The major disadvantages are the usage of voltage above the rate, even during the partial discharge it deteriorates the insulation and causes augmentation in the aging process. To avoid these an online monitoring system is essential for breakdown prediction and to monitor the insulation condition. For this purpose, partial discharge characteristics is used as diagnostic tool for the insulation condition.

The result obtained from the power dynamics is used to set the pre-breakdown condition which is used for disconnecting the power cable with larger defect which can cause the insulation breakdown. Using the common measuring current and voltage transformers it is impossible to measure the partial discharges due to their high inductivity. But the partial discharges have very short pulses of current with the pulse rate measured from nanoseconds to millisecond a sensor must be constructed in this method for an effective implementation of the system.

Various considerations for the electrical signals include the signal recording and processing using software and hardware, data transmission speed, large data level etc. Various technical specifications are also taken into consideration while using the current and voltage sensor. The greatest difficulty lies while calculating the power dynamics and here various bridge circuit are used for the process of removing the noise.

Manaf Atharparvez, Kedar R Purandare, "Series Arc Fault Detection Using Novel Signature Processing Technique", 2018[11]

A low current electric fault can be considered as a hazardous phenomenon in the electric system,which is mostly caused by the loose connections or degrading insulations. It creates a high intensity heat, which serves as the main reason for the fire accidents in the house as it is capable of igniting the surrounding materials that are near the wiring system. It can also have a serious effect on the electrical appliances and may cause loss of property and life. The series arc fault in the electrical system may cause an imbalance in the magnitude as well as the frequency.

Here a signal processing approach is taken in order to provide a method in which the signal characteristics of the wire is compared with the normal condition and the fault condition in the wire. The signal characteristics that changes when a low intensity fault is occurred in the system are current RMS and time average. The waveform for various characteristics is recorded and the deviation is found.

In the series arc fault, the current in the wire is limited by the resistance which cannot be found by the circuit breaker. The solution is based on the integrator circuit which provides the total charge of the positi ve and negative cycles. The charge generation for both half cycles is monitored in order to find the deviation from the normal condition. The presence of arcing in the system causes a change in the magnitude level as well as the frequency of the current in the power line. Here, the analyzing of the power frequency is done during the series arc faults and also the change in the values when different loads are applied to it. They will be verified with the experimental data that has tabulated for various loads and the difference in them will tell where the fault is located in the electrical system.

III. EXISTING SYSTEMS

Most of the wiring faults are hidden behind walls, panels and are generally hard to find. Locating these faults is difficult, as these faults are detected only when they are active. Some of the existing systems are:

Arc-fault Circuit Breaker (AFCI) devices are becoming routine in industry. Although AFCI devices reduce the risk of fire, it will not able to prevent the trip or find and repair the wiring fault after they trip.

The tracer method is one of the faults locating methods in which the damaged segment is found by walking through the cable circuits.

The faulted segment is determined from audible or electromagnetic signals. This method requires manual tracing which is one of the main drawbacks. Thus, this method is not widely used.

The terminal method is a technique used to determine the fault location of a distribution cable network from one or both the ends without actually tracing. This method was discovered to overcome the disadvantage of the tracer method. But it was unable to give the accurate location of the wire fault.

Fault sensing circuit module makes use of set of switches at equivalent distances indicated by a set of resistors to cross check the accuracy. This circuit uses four sets of resistors in series for each phase of the cable line. Since this method requires set of switches and resistors, it is cost inefficient.

Another system which uses Ohm's law to detect the fault in housing wire. When the fault occurs, the varying voltage is used to detect the location of that fault. This system model consists of a microcontroller, Wi-Fi module and a Real-Time Clock. The power supply is provided using step down transformer, rectifier, and regulator.

The voltage drop across the resistors is fed to the microcontroller and based on the voltage the fault is located.

IV. PROPOSED SOLUTION

The faults in the wire are hidden behind the walls and the panels, which causes difficulty in finding them. To identify them, we have seen the existing methods that are presently in use. The current system uses a tracer method which is used to locate the faults by walking through the cable circuits. It involves a manual work and takes lot of effort and time to find the fault in the system. There is an electrical sensing method in which a set of switches and resistors are present at an equivalent distance in order to check the flow of current and their value. It is cost inefficient as it involves purchasing of large number of components. Though these methods locate them, they take more time, cost inefficient and also involves some manual work. Here, we have created a model called SESI, Smart Electric Sensing in Infrastructure, which uses the transistors and the Arduino to find the faults in the electric system.

In our model, we provide with the distance at which the fault is located from the junctions. In a house, to provide easy connections among the different parts, junctions are provided for each and every particular area in the house. These junctions provide as a central point for the wire and the appliances that are seen around them. Only from the junctions, the wires will be given to the nearby switchboards.

If any defect arises in the wiring system, the present system takes the damaged wire only from the main board of the wiring system. This takes lots of effort and manual work in order to change the whole length of the wire.vIn our system, as we analyze the distance at which the fault has occurred form the junction, it will be easy to change the wire from the junction, not from the main board. It reduces the manual work and time involved in rectifying the error.Our model consists of two main modules, namely, the Junction spotter kit and the Surveillance kit. To each junction of the house, a junction spotter kit is fixed in order to continuously the health of the wire. And the Surveillance kit is placed near the main board of the house where the actual processing of the data occurs. It processes near which junction the fault has occurred.The surveillance kit consists of a switch. It is attached to the circuit breaker in order to monitor the overloading of current. When such condition arises in the system, normally the circuit breaker drops. But here, once the circuit breaker drops down, the switch is turned on. It passes a desired value of current through the junctions.The junction spotter kit consists of the BC547 NPN transistor and a resistor. They are fitted to all the junctions of the system. When the current value drops in the transistor, the switch closes and the Read pin of Arduino changes to +5V. The junction that passes the voltage value is considered to be where the fault is. The junction with the fault is displayed in the LCD display.

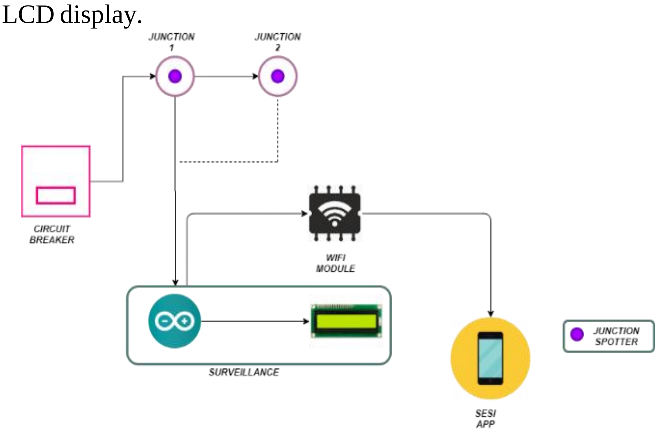


Fig: Architecture of SESI

V. MODULES

Our product, SESI, consists of power supply, a switch, BC547 NPN transistors, Arduino UNO and an LCD display. We have considered the power supply as the voltage that is being given to the house. There are two major parts in SESI, the Surveillance Kit and the Junction Spotter Kit.

A. Module 1: Surveillance Kit

The surveillance kit consists of switch, Arduino UNO and the LCD display. The switch of the kit is attached to the circuit breaker of the main board of the electric system of the house. Whenever an overload occurs in any part, the circuit breaker drops and the switch gets turned on so that voltage is passed through the circuit. The Arduino UNO is used for processing the data that has been sent from the Spotter kit. The Arduino is coded with all the junctions marked in the house. Whenever the Read pin of the Arduino reads a value of +5v, it means that the junction that passes the +5v is where the fault is. Then the junction with the fault will be displayed in the LCD.

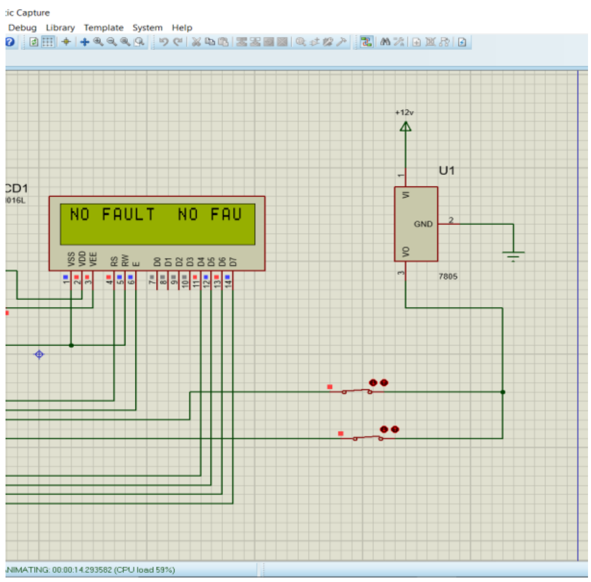
B. Module 2: Junction Spotter Kit

The Junction Spotters consists of the BC547 NPN transistors, electromagnetic switch and resistor. These junction spotters can be fitted in any junction of the house. The BC547 NPN transistor is used as it has a threshold voltage of 0.7V which can be used to easily maintain the voltage throughout the circuit. The transistor has emitter, base and collector. The base is connected to the circuit and the collector is grounded. The emitter of the transistor is connected to the -12v from the supply. Whenever the voltage passes through the iron rod, it creates a magnetic field around it and the rod now acts as a magnet. Now the rod acts as switch. The switch is needed in order to complete the circuit so that the junction that completes the circuit is where the fault has occurred.

VI. RESULT

The above idea has been created into a small and efficient model for the purpose of demonstration. The model consists of the surveillance kit and the junction spotter kit as mentioned in the architecture and this model has been simulated using proteus. The below mentioned conditions has been tested in order to ensure correct working of the product. We have used Arduino , LCD display and the two switches which act as two junctions and their status are displayed in the LCD display.

A. CONDITION 1: When there is no fault in the junctions then thee LCD display will display “NO FAULT”



CONDITION 2: If there is fault in junction one then it displays “FAULT AT JUNCTION 1”

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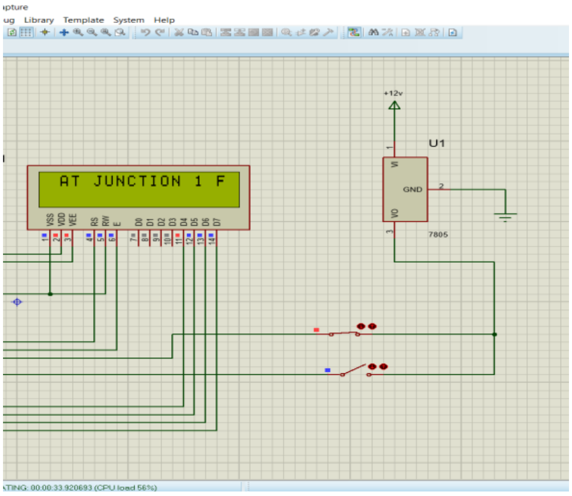
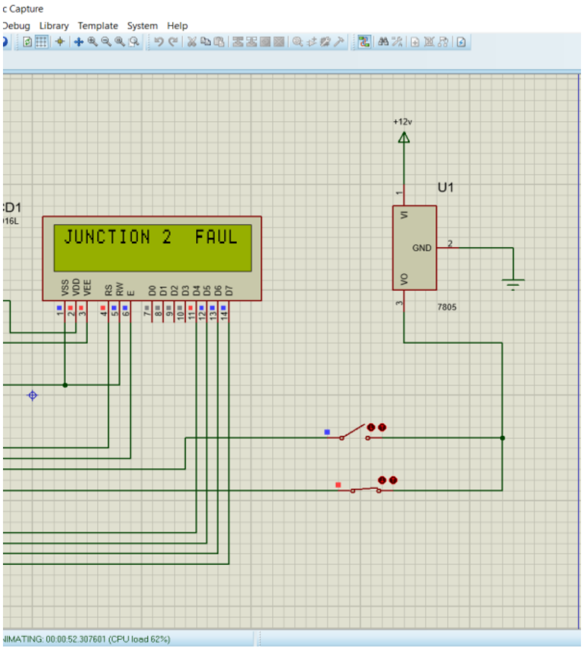
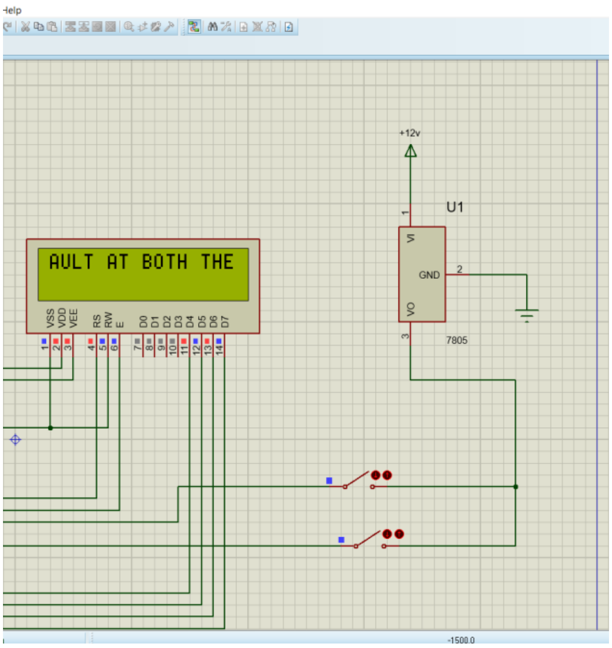


B. CONDITION 3: If there is fault in junction two then it displays "FAULT AT JUNCTION 2"



C. CONDITION 4: If there is fault in junction one and junction two then it displays "FAULT AT BOTH THE JUNCTIONS"



VII. CONCLUSION

Having a monitoring system for continuous monitoring of the health of wires prevents the consequences of having unnoticed wire faults. When a fault has occurred, it reduces the additional time taken to manually run through each wire to detect the place of fault by providing the approximate distance of the fault from the junction. This system replaces all existing techniques that have been used for electrical maintenance with the help of IoT. Further advancements can be made to the proposed system to detect the accurate location of fault.

The sensors have the ability to identify the failures and the sources that produce them sooner before they get into a critical state, so that it increases the capacity of the repair teams and cuts down the other related losses.

The overall expenses that has been spent on the parts for building the system and the repairs are reduced, thus making electricity more accessible and economical. Hence, this system makes the best use of IoT to provide a cost efficient and consistent maintenance measure for smart homes and industries.

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