# Wireless Sensor Network based Fault Diagnosis of Solar based Street Light

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***Abstract:*** Condition Monitoring or Condition based Maintenance is the process of monitoring a parameter of condition in machinery, in order to identify significant change which is indicative of a developing fault. The use of condition monitoring allows maintenance to be scheduled, or other actions to be taken to prevent consequential damages and avoid its consequences. The issue of system maintenance is very important. The proposed system is intended to aid maintenance of renewable energy systems especially on the 'Stand-alone solar street light systems'. Unable to predict the failure, missing parts of the system, and uncertainty in working of the system are the major issues faced by these already installed structures, thus bringing us to a conclusion that the problems related to such systems were principally due to the lack of maintenance. There are many CBM techniques available which are based on Wireless Sensor Networks which require longer battery life, high data rates and less complexity. The existing WSNs based Condition based Maintenance techniques make use of wireless fidelity or Bluetooth which has very high power consumption. The proposed system will prove to be the significant and beneficiary factor in CBM of Standalone solar street light systems.

***Index Terms*** **- Condition based maintenance, wireless sensor networks, Solar based Street Light.**

## I. INTRODUCTION

Condition Based Maintenance (CBM) is a type of maintenance that involves use of sensors to measure the status of a device over time while it is working. The data collected can be used to detect failure and inform the operator about the failure. It is indispensable to monitor and notify the center station about the fault to prevent damage as the cost of components are very much high. Natural cause like lightning strikes, storm, snowfall and heavy rain or even an insect can also damage solar panel and overloading in supply grid can also force power reduction and sometimes shutdowns also. So it is necessary to monitor each and every smallest fault and report it to central station quickly otherwise it leads to large financial losses.

Automation in railway systems based on Wireless Sensor Network (WSN) using Zigbee modules is proposed in [2]. The part of railway to be monitored is connected to WSN node and collected data is uploaded on Webpage. One can access data remotely by using mobile application (Mobile App). The main aim of this work is to monitor the faults in a device by wireless communication The proposal of a solution to both electrical and mechanical faults in an industrial machine is based on WSN is obtained from this paper [3]. The existing system based on the WSNs is short distance communication and needs human interaction. The proposed system has capability to resolve all the issues which happen in the existing methods. In recent years, sensing technologies are distributed widely, whereas the devices are become cheaper [4].The WSN technology can be used for monitoring the railway industry to analyzing systems, structures, vehicles, and machinery. Wireless sensor networks can be used for monitoring the railway infrastructure such as bridges, rail tracks, track beds, and many track equipment along with vehicle health monitoring such as chassis, bogies, wheels and wagons. Main focus is on practical engineering solutions, identification of sensor configurations and network topologies. Wireless sensor network which continuously monitors the railway track through the sensors and detect any abnormality in the track.

A smart remote monitoring system is proposed using Internet of Things (IoT) [5], for monitoring the ordered parameters of Solar Power Unit (SPU).The design and implementation of an interconnected mechanism of SPU and the measurement of the reliable parameters are described. The parameters of the SPU are stored in local work station and are shared with cloud to display the parameters in web link. Main objective of design is a cost-effective system for monitoring the SPU in order to solve management problems, maintenance, fault detection and mean time to repair. The Global System for Mobile (GSM) technology used GSM based Wireless Notice board, the system is attended to be interface with Maintenance officer by using GSM technology with SMS messages, the Maintenance officer can sent the content to be displayed in the SMS and then the message will be informed is mentioned in [6] In the beginning research will focus on describing maintenance and condition monitoring related terms [7]. This thesis focuses on power transformer online condition monitoring. The middle part of the work focus on power transformer structure, fault statistics, condition monitoring methods and measurement devices. Also possibilities of condition monitoring are covered. Also there are opinions about the quality of new transformers that it is decreasing and this would increase transformer failures in the near future.

This work is based on condition monitoring for solar street lights which include the condition of all the devices in one system. The motivation behind this work is given below: The primary motivation of this work is to monitor the condition of solar street lights in remote areas. The condition of systems in a particular area can be observed by a maintenance officer using WSNs. WSNs based CBM system reduce the manual interaction and improve the security, reliability and immediate response at low cost. Real time condition of all the street lights is continuously monitored and updated data in control room for taking corrective action. The main objectives of this work are given below.

- To develop a condition monitoring device for producing an indication of operating conditions of solar powered product.
- To develop a WSN for efficient communication and networking
- To develop a remote monitoring system which will monitor devices placed in solar system depending on day or night time.
- To reduce maintenance cost of solar energy systems by installing our device on the already implemented systems.
- To provide best solution for condition based maintenance of solar energy systems in rural as well as in urban area.

## II. METHODOLOGY

The block diagram of the Device Unit is shown in Fig. 1 which consist of Solar panel• Battery charger• Battery• Bulb• Controller• Monitoring system to each component• Display• Zigbee• GSM(in case of the Master node)•

The proposed system of 'IoT based Condition monitoring of Renewable energy resources (IBCMRER)' is shown in Fig. 1.The main blocks of IBCMRER are given below:

- Multiple Slave nodes (SN)
- One Master Node (MN)
- One Control Unit (CU)

The system is designed to continuously monitor a group of stand-alone solar street lights in a particular area. The blocks diagram in Fig. 1 prototypes the actual system. The individual streetlights are called as nodes. Each node will be provided with its unique address so that it will be easy to locate the street-light. Three nodes are present in this system. Two of them are named as Slave 1 and Slave 2 respectively, and one node is addressed as Master node. The devices present in individual nodes i.e. Solar panel, Battery, Battery Charger and bulb are all connected to the maintenance circuit. The entire nodes serve the same task of monitoring all the mentioned devices continuously except for the Master node with comes with additional functions. Consider a fault has occurred in either of the devices, each device will represent a switch which will either turn on or off according to the logic embedded in them. This data will be transferred from Slave nodes to the Master nodes using Wireless Sensor Network (WSN). Master node receives all the Slave node data (solar panel, bulb, battery and charger status) form the nearby Slave nodes and transfers this data to the maintenance officer using GSM also displayed through GUI design in Visual Basic software.

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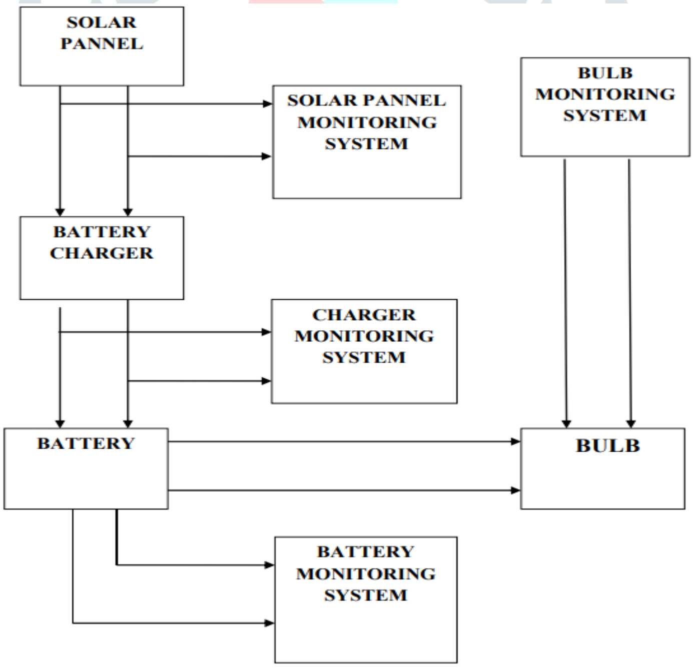


Fig. 1: Block Diagram

## III. IMPLEMENTATION OF HARDWARE AND SOFTWARE

The implementation of the circuit hardware consists of two parts; both the circuits will be installed on the nodes i.e. stand-alone street lights:

A. Monitoring device
B. Controller unit

The monitoring device: This circuitry monitors solar panel, Battery charger, Battery and bulb. Fault detection and sending the fault signal will be the two functions performed by this device.

Circuit design description: Stand-alone solar street lights will be tested for two conditions, one during the day time and another during the night time. Different components of the system will be monitored in these two conditions. Depending upon Day time and night time conditions the monitoring device will also consider two conditions:

1. Day condition: During day time it will monitor solar panel, battery and battery charger.
2. Night condition: during night time it will monitor the bulb.

These two conditions will be determined by a simple light detection circuit. Controller device: Controller device is used for processing of signals coming from the maintenance device. After processing only the faulty signals will be considered and forwarded to the master. Trans-receiver functions of Zigbee will be carried out in controller device.

The algorithms for Slave node, Master node are given below which is also presented in the form of a flowchart.

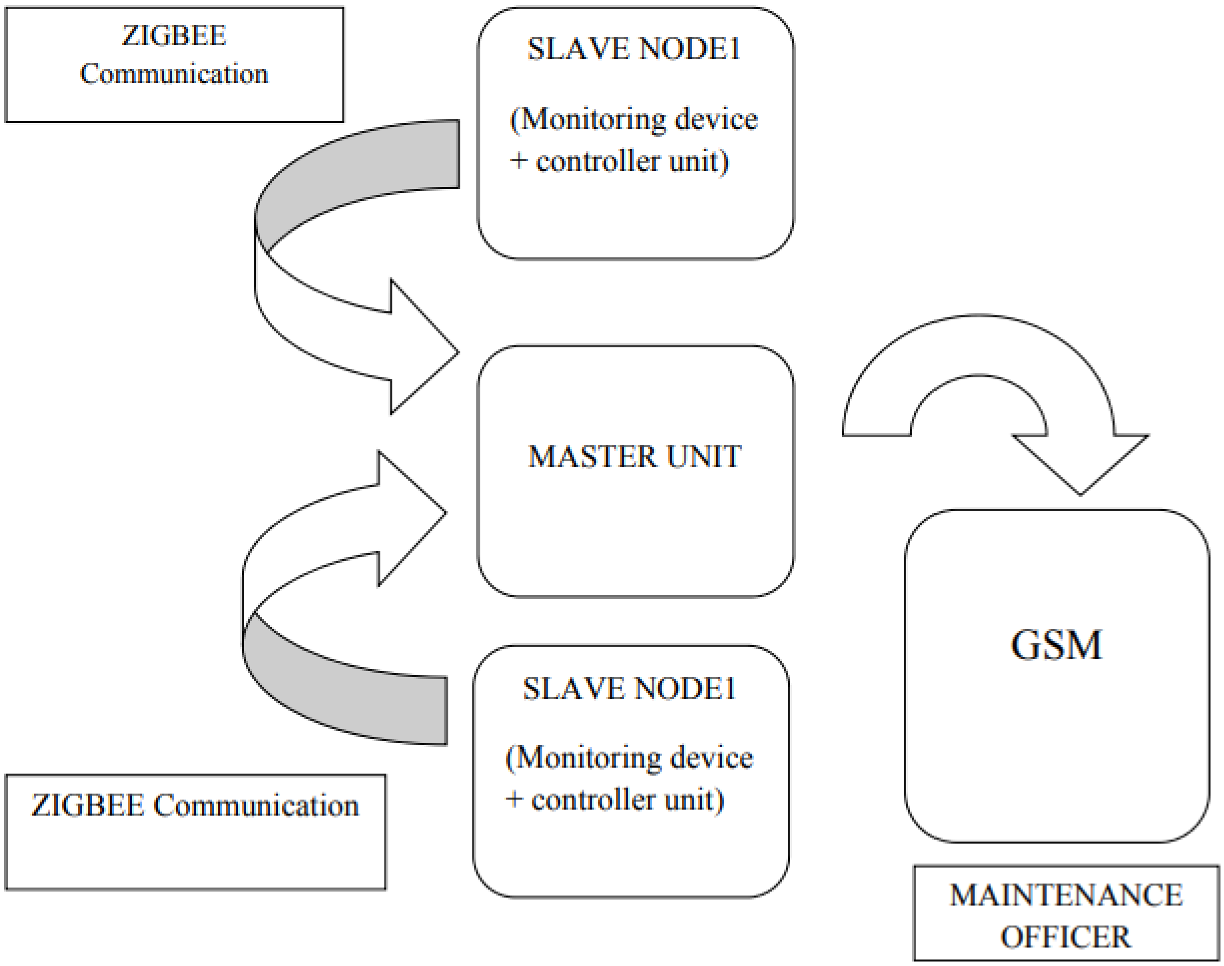


Fig. 2: Flow of communication between devices

The operation of the system is as follows: As there are 3 Devices: Slave 1- Detects and sends the fault condition (if occurred) using Zigbee to the Master node which is having Trans-receiver Zigbee module. Slave 2- Detects and sends the fault condition (if occurred) using Zigbee to the Master node which is having Trans-receiver Zigbee module. Master - Only one node in a particular area will be addressed as the Master node. This particular node will be communicating with the Maintenance officer. At the end the Master node will be having Data of first Slave node as well as second Slave node and the sensor values of its own unit. The Master node will then send all the sensor values and status of devices to the Maintenance officer using GSM link. Master node will also communicate with another user with the help of Visual basics and display the output using Graphical user interface (GUI). This software will create a monitoring window which will display the conditions of all the nodes. Stand-Alone street light systems in a particular area will be installed with a Monitoring device. This unit will function differently for different devices according to the logic embedded in its hardware. The monitoring unit will indicate a detected fault in any of the device. A message regarding fault will be sent to the Maintenance officer. In case of the Slave node the Controller Unit will simply display where the fault has occurred and transmit this condition to the Master node. In Slave nodes the transmission and reception will be done by Zigbee (WSN). The Master node will monitor its own device as well as receive the signals coming from the nearby Slave nodes. The Controller Unit in the Master node will process all the signals and will forward the fault signal to the Maintenance officer in the form of a message using GSM. In a particular area the same logic can be implemented and made more efficient with the help of clustering as shown in Fig. 2, where all the nearby nodes will communicate with one another and finally the signals will be transmitted to the Master node and then will be forwarded to the Maintenance officer via Short Message service (SMS).

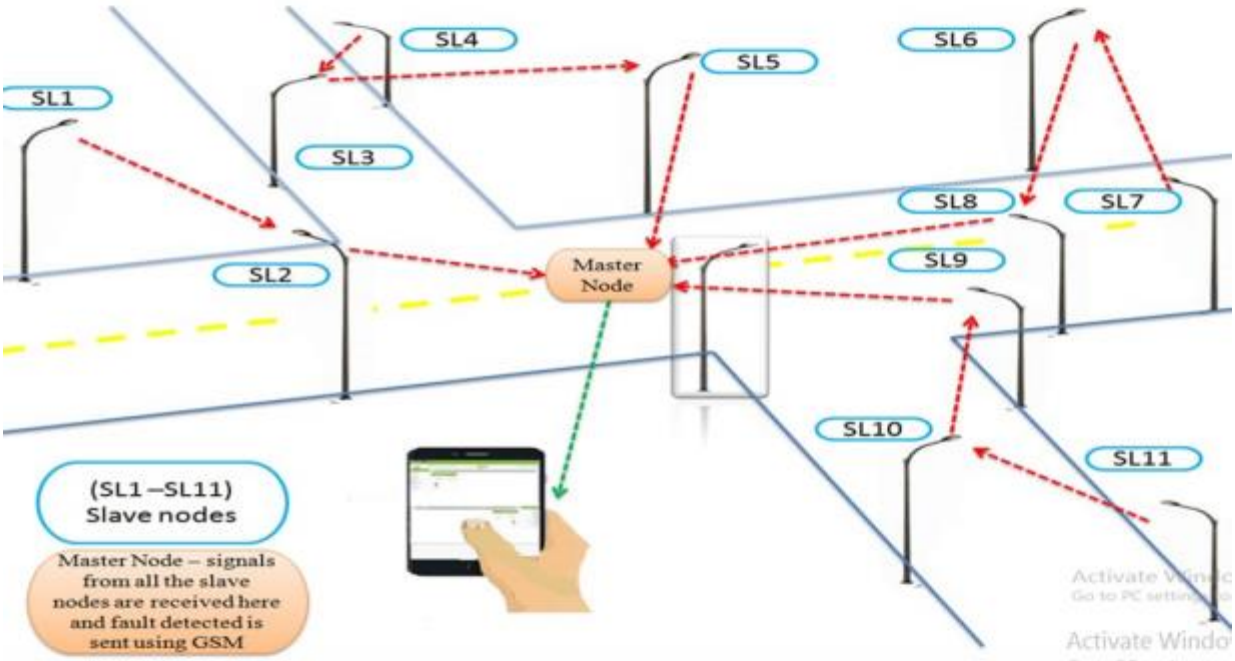


FIG. 2. Clustering diagram

Stand-alone solar street lights will be tested for two conditions, one during the day time and another during the night time. Different components of the system will be monitored in these two conditions. Depending upon Day time and night time conditions the monitoring device will also consider two conditions: 1. Day condition: During day time it will monitor solar panel, battery and battery charger. 2. Night condition: during night time it will monitor the bulb. These two conditions will be determined by a simple light detection circuit.

This circuit consists of Light Dependent Resistor (LDR) and Operational amplifier (Op-Amp LM 358). LDR is a type of resistor whose resistance changes depending on the intensity of the light surrounding it. This component will be placed on the solar panel so that it will detect the presence of light which will determine whether day condition or night condition is to be considered. When light is incident directly on LDR its resistance will be low and when there is no light its resistance jumps to a few MΩ, this acts as the first input to the Op-Amp. Light emitting diode (LED) is used as an indication which will glow during day time and will be off otherwise.10K and 330KΩ resistors are used in the Voltage divider circuit which acts as second input for the Op-Amp. Op-Amp is configured in comparator mode i.e. it will compare the Voltages at inverting and non-inverting terminals and correspondingly generate a high or low output (high day time/ low-night time). After determining the condition, the same signal (high/ low) is forwarded to the entire circuit. 1. Day condition: Two Op-Amps (LM- 358) are used, each for monitoring battery and charger. Also the solar panel is tested during this condition. This circuitry consists of basic gates which act as switches providing low and high outputs to the LEDs and to the controller device. For solar panel, battery and charger high signal output (LED on) is considered as 'OK' condition whereas low signal output (LED off) indicates fault signal.

For monitoring solar panel, NAND IC-7400 is used, one input of which is the input coming from the solar panel and the second input is the Light detection circuit output. The solar panel provides 20 Volt potential when in OK condition. The fault condition is considered when its Voltage drops below 3 Volt. For creating the fault manually, solar panel input is manipulated using a 50KΩ potentiometer. For monitoring battery, NAND IC-7400 along with LM-358 (op-amp) is used. One input to the NAND IC is the LDR circuit output and the second input comes from the Op-Amp. The OpAmp is configured as comparator providing TTL logic output for NAND. It compares the battery Voltage with an independent 5 Volt power supply and provides either low or high signal required by the logic gate. The battery in OK condition will provide 12 Volt potential. The fault condition is considered when its Voltage drops below 5 Volt. Fault in the battery is manually created using a 50KΩ potentiometer. Monitoring circuit for the charger is same as that of the battery circuit but with a change in threshold values for the comparator. Charger testing with no load is neglected and with load testing is considered. It is assumed that the charger is faulty if it fails to provide constant 12 Volt supply in with load condition. Thus the threshold for fault is 10 Volt in case of charger. For creating the fault manually, charger output is manipulated using a 50K potentiometer. Outputs of all the logic gates act as input signals for the controller circuit.

Night condition: Only the bulb is tested in this condition. Op-Amp LM-358 and OR gate IC- 7432 are the main components used in this circuit. The logic for gate operation is determined by a truth table. OR gate acts as a switch providing low and high outputs to the LED and to the controller device. For testing of bulb high signal (LED on) output is considered as 'OK' condition whereas low signal output (LED off) indicates fault signal.

For monitoring bulb, OR gate IC-7432 along with LM-358 is used. One input to the OR gate IC is the LDR circuit output and the second input comes from the Op-Amp. The Op-Amp is configured as comparator providing TTL logic output for NAND. It compares the no load bulb Voltage with an independent 5 Volt power supply and provides either low or high signal required by the logic gate. The bulb in OK condition will be on in night time providing 12 Volt load potential at charger. The fault condition is considered when at night-time the charger Voltage is greater than 12 Volt indicating open circuit (open circuit Voltage at charger during night time = fault in bulb). Fault in the bulb is manually created using a 50KΩ potentiometer.

## IV. RESULTS AND DISCUSSION

In this work all the device conditions are displayed in the control room as well as the message which is sent to the Maintenance officer using Visual Basic (VB) software through GUI design and GSM respectively as shown in Fig. 3. The entire system will be communicating using Zigbee, WSN the monitoring device will be connected to the solar panel, battery, charger and the bulb. Fault generated in any node will be transmitted to the Master node. Initially 111 will be no fault condition and 0 will be indicating fault. This device will be installed in the stand-alone solar systems which will monitor solar panel battery, charger and bulb. It comes with its 5 Volt separate power supply for constant TTL voltage. Master node receives signals from both the Slave nodes. It also checks for the signals coming from its own monitoring device. These signals will be indicating fault conditions of the streetlights. Once all the data is available, GSM module sends message to the maintenance officer and Zigbee sends signals for GUI. Slave node will monitor Street-light system and if fault is generated, signal will be transmitted to master node once the master node will request for communication. Initially it will display name of the node –'Slave node 1'. The condition 111 indicates no fault and 0 indicates fault in a particular device. 011- Fault in Solar panel 101- Fault in Battery 110- Fault in Charger.

Fig. 3. Hardware of proposed system

## V. CONCLUSION

VI. Condition Based Maintenance (CBM) is a type of maintenance that involves use of sensors to measure the status of a device over time while it is working. The data collected can be used to detect failure and inform the operator about the failure. To diagnose the various types of faults occurring in remote location renewable systems, this work describes a monitoring and analysis system. This proposed system will provide the combinational benefits of CBM, WSN and IoT. This proposed system will provide the combinational benefits of CBM, WSN and IoT.

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