**Earthing Integrity Monitoring System for Street Lights**

**Introduction:**

The Earthing Integrity Monitoring System is a comprehensive solution designed to monitor the safety and of earthing systems in street light poles, particularly in parking lots, station areas, and other public spaces. This system aims to detect and address potential earthing issues such as leakage current, continuity loss in earth wire, and abnormal earth resistance, which can pose significant safety risks. The system uses a current transformer to measure leakage current, a voltage injection method with a reference resistor to check earthing continuity, and earth resistance calculation to monitor overall system health. Upon detecting a fault, such as a leakage current or earth resistance problem, the system generates alerts and communicates the issue to a centralized monitoring location via GSM communication. In the future, the system will integrate Powerline Communication (PLC) for more efficient data transmission using existing power lines. The solution is designed to be cost-effective, scalable, and easy to deploy, providing a reliable method for ensuring the safety and proper functioning of street light pole earthing systems. It reduces maintenance costs, improves safety, and ensures compliance with electrical standards by offering early detection of potential faults.

**Components Required:**

Microcontroller: Arduino UNO

Current Transformer

Op-amps

Low pass Filter

Resistors

Capacitors

MOSFET

GSM Module: SIM800L

Sim card

**Methodology:**

The Earthing Integrity Monitoring System is designed to continuously monitor the earthing system of street lights, detect faults, and send alerts to a centralized location.

The system measures **leakage current** using a Current Transformer, which operates based on a turns ratio of 1000:1. The CT is clamped around the phase and neutral wires, where it senses any leakage current that may flow through the street light system. The CT is designed to generate a secondary current that is 1/1000th of the primary current, reflecting the leakage current flowing through the conductor.

The secondary current of the CT is then passed through a burden resistor. The burden resistor is crucial as it transforms the secondary current of the CT into a measurable voltage. The value of the burden resistor is chosen based on the expected range of leakage current. A 1kΩ resistor is typically used in the system to ensure the voltage generated is within the operational range of the microcontroller’s ADC converter.

After the voltage is generated across the burden resistor, the signal is fed into an operational amplifier for amplification. This is necessary because the voltage generated across the burden resistor is typically low and requires amplification to be detected accurately by the Arduino’s ADC. The Op-Amp is configured with a gain that is optimized to provide an appropriate voltage level for the Arduino to process.

To ensure precision and minimize errors, a low-pass filter is used to smooth the amplified signal and eliminate any high-frequency noise that may interfere with the measurement. The filtered signal is then passed to the microcontroller’s ADC, where it is digitized for further processing.

Software rectification is employed to convert the AC signal from the CT to a DC value that represents the magnitude of the leakage current. The rectified value is then used to calculate the leakage current.

In the software, the gain compensation is applied to account for any variations in the CT’s output characteristics or inaccuracies in the system setup. This ensures that the leakage current is calculated accurately, even in cases of minor fluctuations in the CT output.

The **continuity of earthing** in the system is tested by injecting a controlled voltage into one side of the earthing path, as the other side is connected to the pit, making it inaccessible. A 9V power supply is used to apply the voltage through a MOSFET, which is controlled by the Arduino to ensure the current flows only during testing. Once the voltage is injected, a 1kΩ reference resistor is placed in series with the earth conductor to measure the voltage drop, which corresponds to the current flowing through the earthing system. A continuous and low-resistance earth path will allow the current to flow within the expected range. Any fault, such as a high-resistance or broken earth path, will result in a lower current, signaling an issue. The Arduino processes the voltage readings and compares them to predefined thresholds to detect faults. If a fault is detected, the system sends an alert via a GSM module to notify the appropriate personnel. The MOSFET ensures that the voltage injection is applied only during the test, switching off once the test is completed. This method ensures the efficient and reliable testing of the earthing system's continuity.

**Earth resistance** is calculated using the voltage drop across the reference resistor, with the system utilizing Ohm's Law to compute the resistance. The system measures the current flowing through the resistor during the test and determines the earth resistance based on the known value of the resistor.

The system processes all measurements within the Arduino Uno. If any fault is detected (such as excessive leakage current or high earth resistance), the system sends an alert via the GSM module (SIM800L) to a mobile phone or a centralized server.

**Claims:**

**Claim 1:**An earthing integrity monitoring system comprising: a sensing module configured to detect and measure leakage current associated with electrical streetlight installations; a current transformer having a turns ratio of 1000:1, operable to sense current flow through phase and neutral conductors, wherein the current transformer outputs an signal proportional to the detected current; a burden resistor operatively coupled to the current transformer to convert the induced current into a measurable voltage signal; and an amplification and filtering circuit including an operational amplifier with a gain factor to compensate for weak signals, wherein the circuit further includes a low-pass filter to suppress high-frequency noise and enhance signal clarity.

**Claim 2:**The system of claim 1, wherein the processing unit is configured to receive the filtered signal and programmed to perform software-based rectification for accurately determining the presence and magnitude of leakage current, classify the severity of the leakage, and generate alerts indicative of potential faults; wherein the system further comprises a processing algorithm designed to adaptively adjust gain compensation based on signal strength and environmental conditions, providing enhanced measurement accuracy and reliability.

**Claim 3:** An earthing continuity verification system comprising: a voltage injection mechanism operable to apply a test voltage to the grounding network; a reference resistor and sensing circuit configured to measure the current response to the applied test voltage; and a processing unit programmed to determine the continuity of earthing by analysing the measured current and comparing it to predefined thresholds, wherein the system can access only one end of the earthing wire and generates fault alerts if earthing continuity is compromised.

**Claim 3:** An earth resistance measurement system comprising: a resistive voltage divider network coupled to the ground system of an electrical installation; a microcontroller configured to calculate the resistance of the grounding system based on the voltage and current parameters derived from the resistive divider; and a reporting mechanism to indicate whether the measured resistance is within acceptable safety limits, wherein the system operates without requiring manual calibration for routine measurements.

**Claim 4:** An integrated control system for monitoring and managing streetlight installations, comprising: a fault detection subsystem capable of identifying anomalies in leakage current, earthing continuity, and earth resistance; an automated mechanism for isolating faulty poles upon detecting hazardous conditions; and a communication module configured to transmit status updates and fault notifications to a centralized monitoring system, wherein the integrated control system transitions seamlessly between monitoring, fault detection, and communication modes.

**Claim 5:** A comprehensive monitoring framework for interconnected streetlight installations, wherein the system monitors leakage current, earthing continuity, and earth resistance simultaneously using shared processing resources; the measurements of all three parameters are correlated to identify compound faults or system-wide issues; and the system is programmed to prioritize critical alerts based on the combined analysis of the monitored parameters.

**Claim 6:** A communication module for earthing integrity monitoring systems, wherein GSM is the primary mode of communication for transmitting data to a centralized control unit, and the system is also designed with provisions for future integration of powerline communication (PLC) as an alternative communication method.

**Claim 7:** A retrofit earthing integrity monitoring system for existing streetlight installations, wherein the system is designed for seamless integration without requiring modifications to the original streetlight structure or wiring; the system utilizes non-invasive sensors and externally mountable modules to perform leakage current detection, earthing continuity verification, and earth resistance measurement while maintaining the operational integrity of the streetlight.

**Claim 8:** A fault-responsive earthing integrity monitoring system comprising: an environmental sensor suite integrated to measure ambient conditions that may affect grounding performance; a processing unit configured to correlate environmental data with grounding fault metrics; and a control mechanism that adjusts system sensitivity or initiates precautionary alerts based on environmental fluctuations, ensuring enhanced reliability in diverse operating conditions.

**Claim 9:** An intelligent grounding diagnostic system comprising: a multi-sensor array for real-time detection of electrical and environmental parameters related to grounding health; an onboard data analytics module employing machine learning algorithms to predict potential faults and degradation trends in the earthing system; and a user interface for displaying predictive maintenance recommendations, wherein the system enhances operational safety and reduces maintenance costs.

**Claim 10:** A scalable earthing integrity monitoring network comprising: multiple node devices installed at individual streetlights, each node equipped with sensing, processing, and communication capabilities; a centralized monitoring server for aggregating and analysing data from all node devices; and a hierarchical alert mechanism to notify maintenance personnel of localized or network-wide issues, wherein the network architecture supports seamless expansion to accommodate additional streetlights.

**Description:**

The invention pertains to an advanced monitoring system for assessing the integrity of earthing in electrical streetlight installations, specifically designed to identify leakage currents, assess earthing continuity, and measure earth resistance. This system is intended for use in outdoor electrical setups, such as those found in parking lots and station areas, where maintaining an effective earthing system is crucial for safety. The system incorporates a sensing mechanism that identifies and quantifies leakage currents, which are indicative of faults in the earthing system. A core component is a current transformer with a 1000:1 turns ratio, enabling it to detect current flow through both the phase and neutral conductors. This transformer generates an signal, proportional to the current flowing through the system. A burden resistor is then connected to the current transformer to translate the current into a measurable voltage signal, even when the current is weak. This signal is subsequently fed into an amplification circuit where an operational amplifier boosts the signal strength, compensating for any minimal or attenuated signal. In addition, a low-pass filter is incorporated to suppress high-frequency interference, ensuring that the signal remains clean and accurate for further analysis. The processed signal is sent to a processing unit that is responsible for evaluating the strength and characteristics of the leakage current. Through software-based rectification, the system converts the alternating current signal into a direct current measurement, improving the precision of leakage current detection. The system then analyses the magnitude of the detected leakage and classifies its severity based on predefined thresholds. In cases where the leakage exceeds safe limits, alerts are generated to notify maintenance personnel or operators of potential faults. To adapt to varying conditions, the system can dynamically adjust its settings, including gain compensation, to maintain accuracy in different environments. This innovation enhances the overall safety and reliability of streetlight earthing systems by providing continuous, real-time monitoring, while offering a cost-effective solution that minimizes the need for complex hardware. The system’s ability to identify faults early and classify their severity ensures that corrective actions can be taken promptly, reducing risks and maintaining compliance with safety standards. This monitoring technology is especially beneficial for urban infrastructure, where it can be integrated into smart city solutions, enabling centralized oversight of public electrical installations.