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# High Voltage Transmission Line Protection and Condition Monitoring of Substation Grounding Grid

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**ABSTRACT:** Grounding grid of a substation is essential for reducing the ground potential rises inside and outside the substation during a short-circuit event. The performance of a grounding grid is affected by a number of factors, such as the soil conductivity and grounding rod corrosion. Industry always has a strong desire for a reliable and cost-effective method to monitor the condition of a grounding grid to ensure personnel safety and prevent equipment damage. In view of the increased adoption of telecom and sensor technologies in power industry through the smart grid initiative, we propose a monitoring scheme for grounding grids. The scheme monitors touch and step voltages in substation through VI measurement. The test current is taken from the transmission line and injected into the grounding grid via step down transformer. The grid performance is monitored by measuring the VI after the signal injection. The overloading error or any other short circuit problem is overcome by turning off the circuit. This is done by comparing the line voltage with the threshold voltage. If the value is above the threshold level then to reduce the component loss the circuit is turn off. Computer simulation studies have shown that the proposed scheme is highly feasible and technicallyattractive.
**Keywords:** Condition monitoring, Substation, Transmission line and Grid

## I. INTRODUCTION

Prime objective of earthing is to provide a zero-potential surface around the area where the electrical equipment is installed [1-3]. To achieve this objective the non-current carrying parts of the electrical equipment is connected to the general mass of the earth which prevents the appearance of dangerous voltage on the enclosures and helps to provide safety to working staff and public [4].

Ground faults due to leakage current are the electrical currents that have differing paths to the ground in a specific area and can have dangerous results on nearby electrical machinery and fuses [5]. Their detection requires sophisticated electronic equipment, its readings or results may be complex to decipher. In addition, this equipment is expensive, and it may be best to leave the detecting of ground faults to professionals. Ground fault detection is conducted normally by readings from either a zero-sequence transformer or a processor capable of processing all circuit breaker information in a given region [6-8].

All of the aforementioned methods are offline-based, which at best give one- shot measurement results, if another set of result is needed, the measurement system must be redeployed. The offline-based methods have significant disadvantages,

- Firstly, the results are largely dependent on the soil condition at the time ofmeasurement.
- Secondly, sudden changes of the grounding grid such as those caused by theft cannot be identifiedtimely.

In this proposed method of monitoring of substation grounding grid by using voltage measurement, which can inject testing current into a grounding grid and then measure the corresponding touch and step voltages. The testing current is created by a thyristor-based signal generator which is connected between single energized phase conductor and ground to stage a temporary and controllable fault [9-10].

There is no extra cable needed for current flow as power line as well as in case of remote injection ground is utilized as a path for current injection. Touch and Step voltages, which directly reflect operational safety of substation, are used as indicators of grounding conditions.

## II. MATERIALS AND METHODS

### CURRENTDISTRIBUTION

In the remote injection scheme, a temporary fault is staged at downstream of the

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under-test substation to create a fault current flowing from the faulted phase to ground and back to the substation. However, with the presence of the multiple grounded points on the neutral, such as pole grounds and transformer grounds, the current is divided before reaching the substation grounding grid. The process of the proposed online monitoring scheme includes.

- Testing current generation andinjection
- Touch voltage and step voltagemeasurement
- Trimming of the circuit with the faultdetection

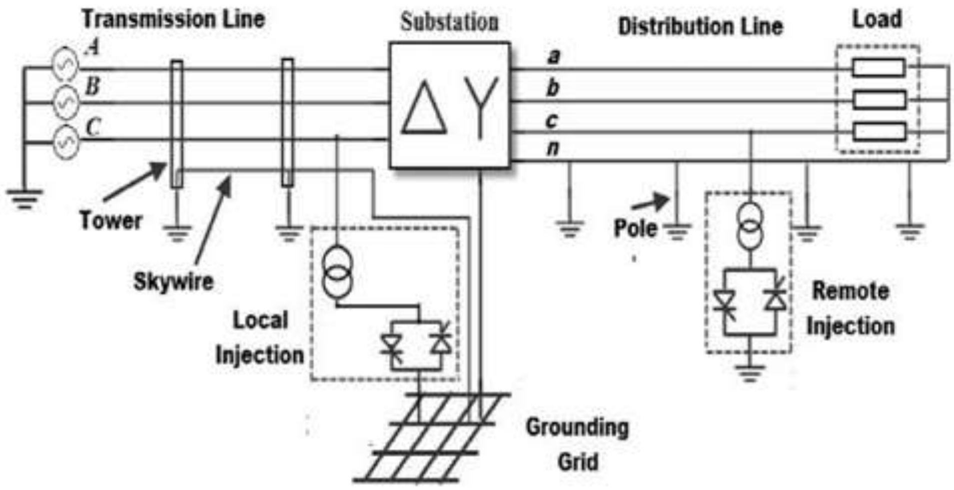


**Fig.1** Design of proposed method

In Figure 1, the measurement of voltages does not require long cables extending outside of a substation, it is very suitable for long-term online monitoring. Supported by the historical data made available through the online database which wirelessly communicate with the voltage sensors, the variation of the measured data can be used to infer the change of grounding gridconditions.

**Layout Of The Proposedsystem**
**The lay out of the proposed system is shown in Figure 2.**

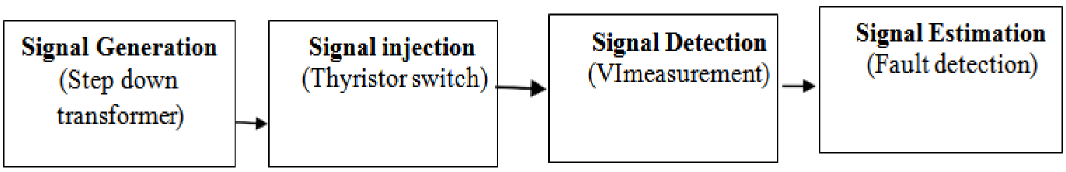


**Fig .2.** Block Diagram

- Signal Generation
- Signal Injection
- Signal Detection
- Signal Estimation

**Signalestimation**

Estimation is carried out by comparing the measured values with the standard threshold value. As the injected current through the grounding grid is actually about 50 – 100 A, the concern here is if the 50 – 100 A current is able to result in the detectable touch/step voltage. The grounding profile is obtained with 50 A grounding grid current, which causes the touch voltage between 3 – 13 V. The voltage in this range can be easily detected by the voltage measurements. For safety evaluation, the actual voltages are scaled up to the maximumvalues.

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**Workingprocedure**

- Generate and inject a testing current into a grounding grid periodically, Measure the resulting touch and stepvoltages.
- Scale the measured values to the maximum range of Touch/Stepvoltages
- Compare the maximum measured voltage values with the threshold values under the same parameters, like fault clearing time and the body weight,etc.
- If it exceeds the safe value a warning event is created and the suspected locations is reported to substation operators for furtheranalysis
- Compare the measured touch/step voltage values with the historical data at the samelocation

In Figures 3 and 4 Simulink Verification and Validation enables systematic verification and validation of models through modeling style checking, requirements traceability and model coverage analysis. Simulink Design Verifier uses formal methods to identify design errors like integer overflow, division by zero and dead logic, and generates test case scenarios for model checking within the Simulink environment.

**Blockdiagram**

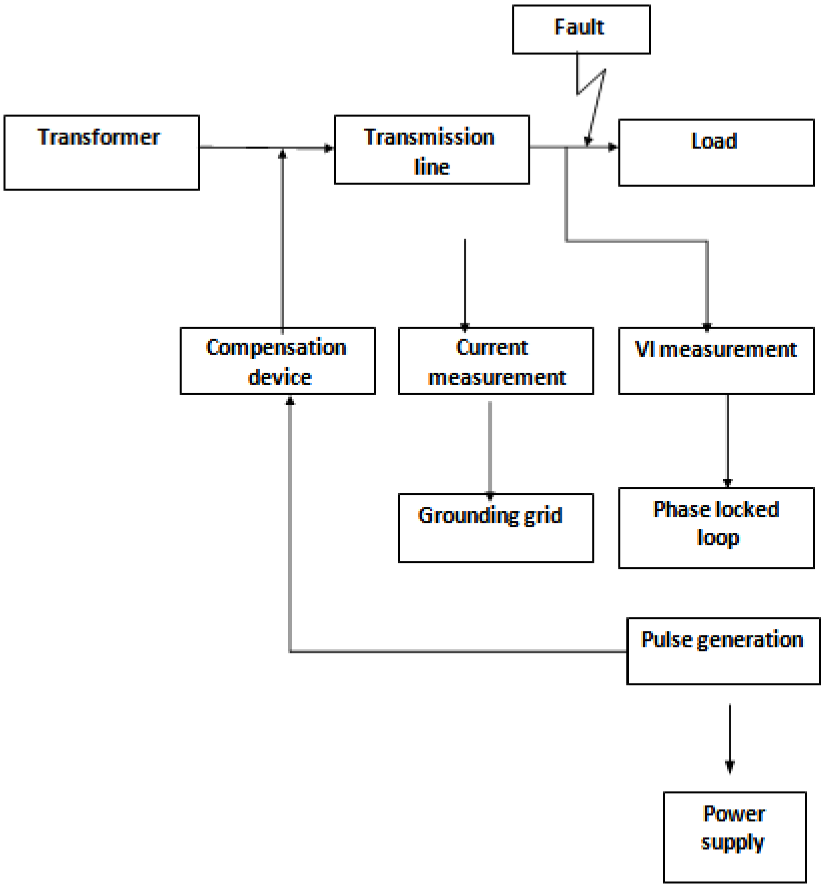


**Fig.3.** Block Diagram

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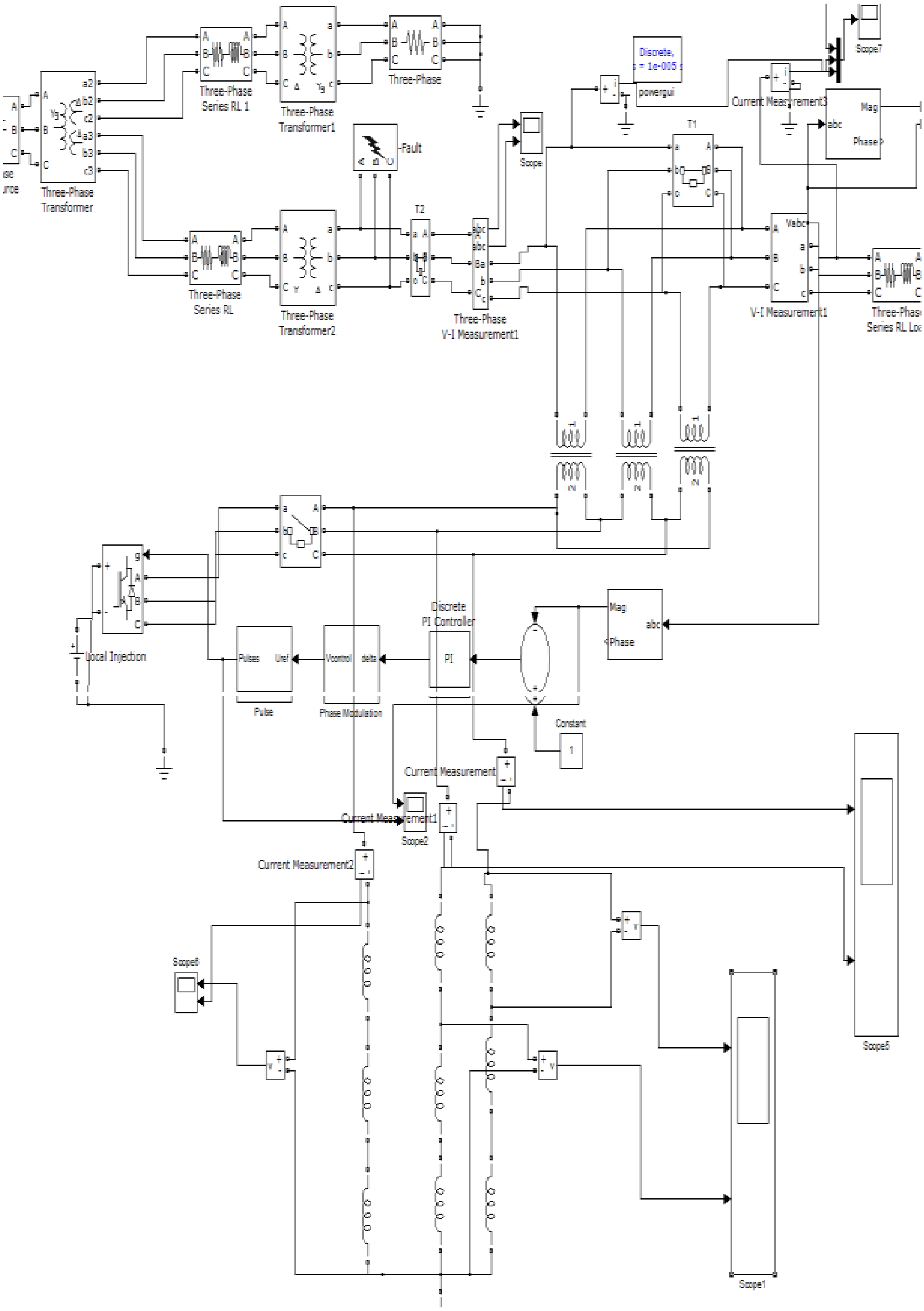


**Fig. 4:** VI measurement

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The line-to-ground capacitors provide a path for 50/50Hz current to flow to the chassis. As long as the equipment is grounded, these currents will flow in the ground circuit and present no hazard. However, in the unlikely but always possible circumstance where the ground circuit is faulty, the earth connection may be established by the body of a person. If this should occur, the maximum leakage current specification limits the ground return current to a safe value. The results are shown in Figures from 5 to 9.

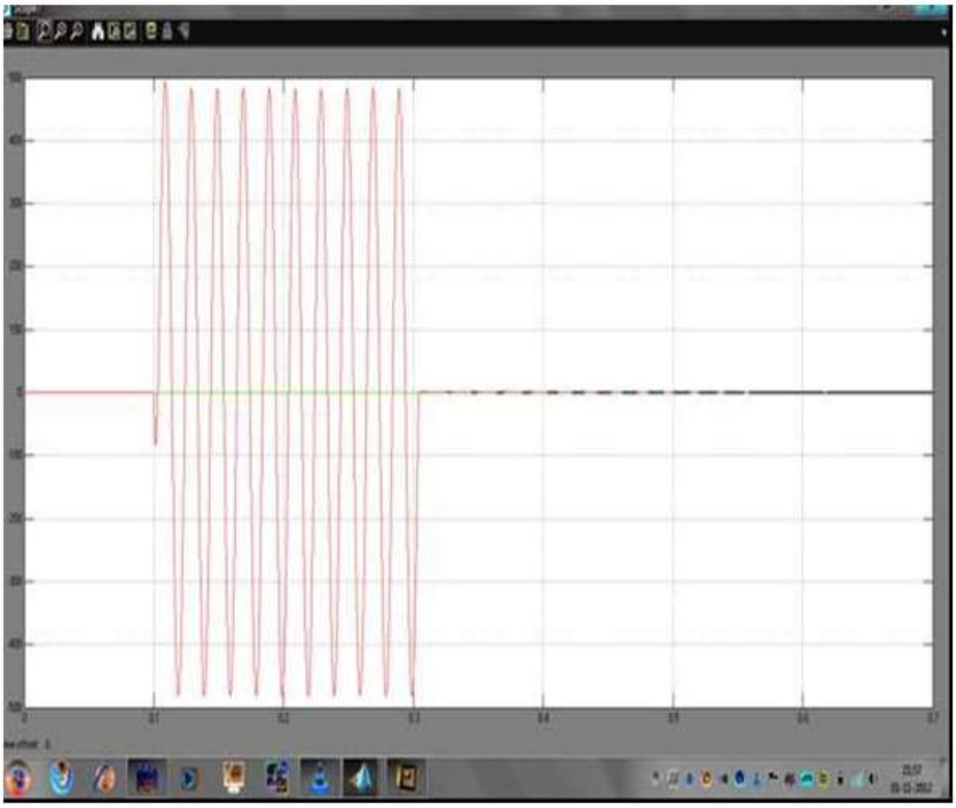

**Fig. 5:** Leakage Current

The output waveform indicates the presence of error at the grounding. It is found from the graph that there is leakage of current at the grounding. To overcome the current leakage, a compensating current is provided by the thyristor switch. The error is due to the leakage of current in the grounding path. Leakage of current is defined by the output voltage is less than the appliedvoltage. This can be avoided by providing compensation current via thyristor in the signal generator block. The compensation is shown in output waveform after the occurrence of error.

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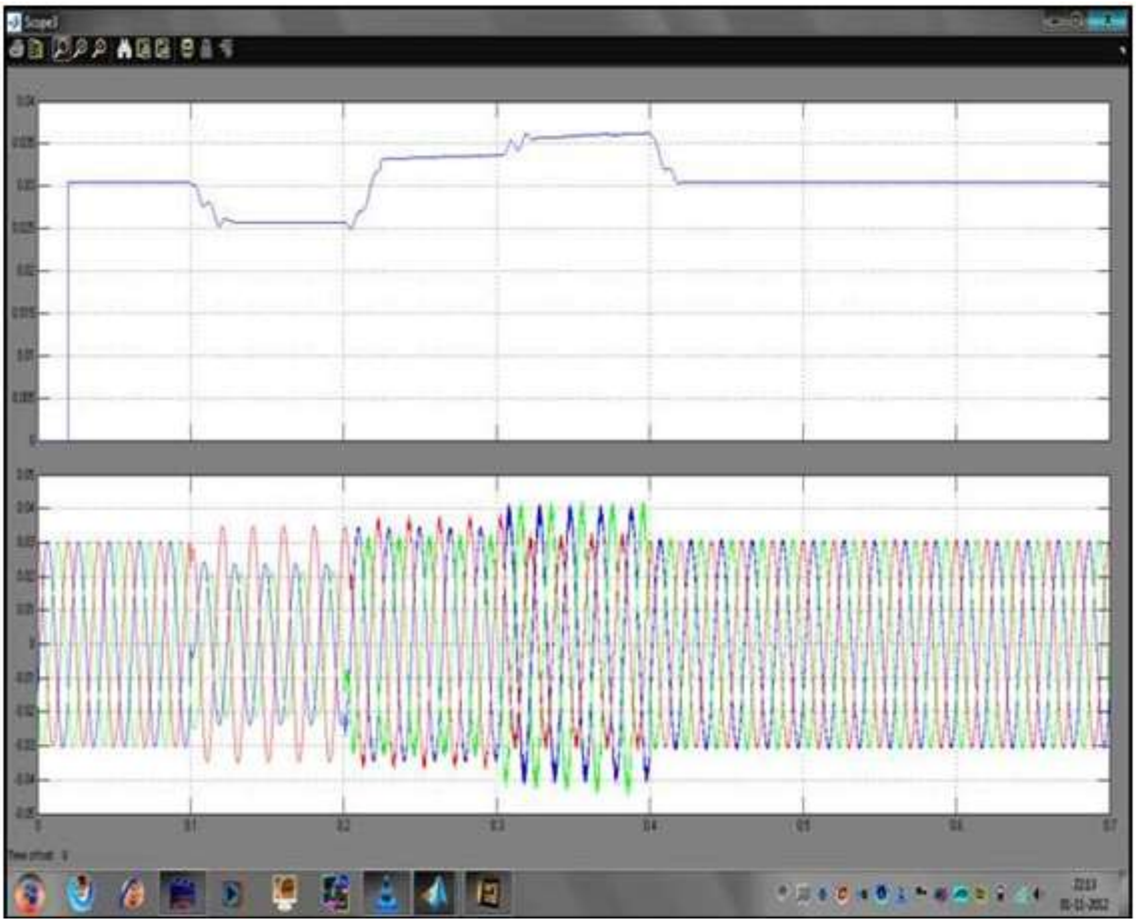

**Fig. 6:** Compensation of Leakage Current

From the output voltage waveform it is observed that the voltage decreases due to leakage of grounding current. The compensation current is taken from the phase line itself. The breaker circuit is used to connect the thrysitor to the linear transformer. The compensation current increases the voltage beyond the original value and it is shown above, the compensation current overcome the error at the output due to leakage of current toground.

**Trim Off Thecircuit**

Even though by providing compensation of the leakage current, there may be possibility of occurrence of damage to the internal and external equipment's. Hence it is arranged so that proper trimming takes place by using a breaker circuit to turn off the circuit. The compensation current is provided only for a small mean while after that the switching off the circuit is takes place. The following figure shows that trimming of the circuit after the detection of leakagecurrent.

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**Fig.7:** Turn off the circuit

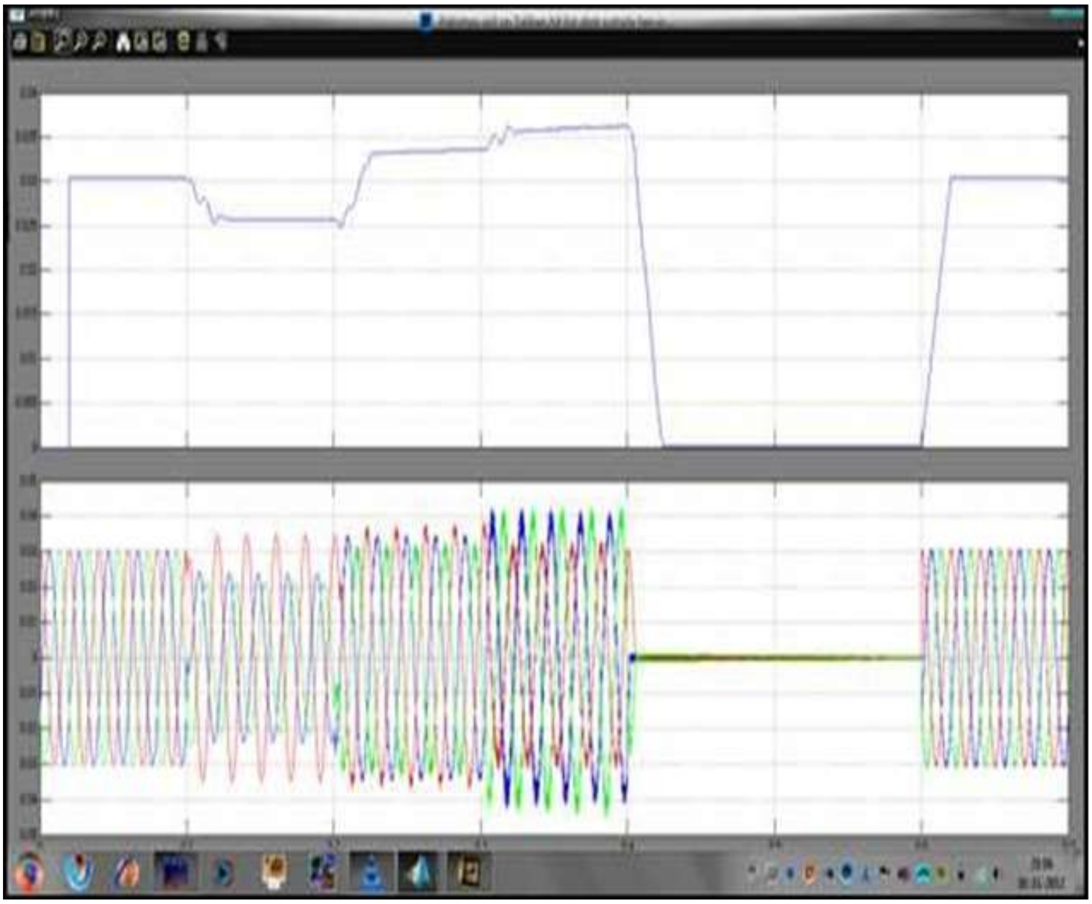

**Fig. 8 :** Output of the voltage flowing through the grounding grid

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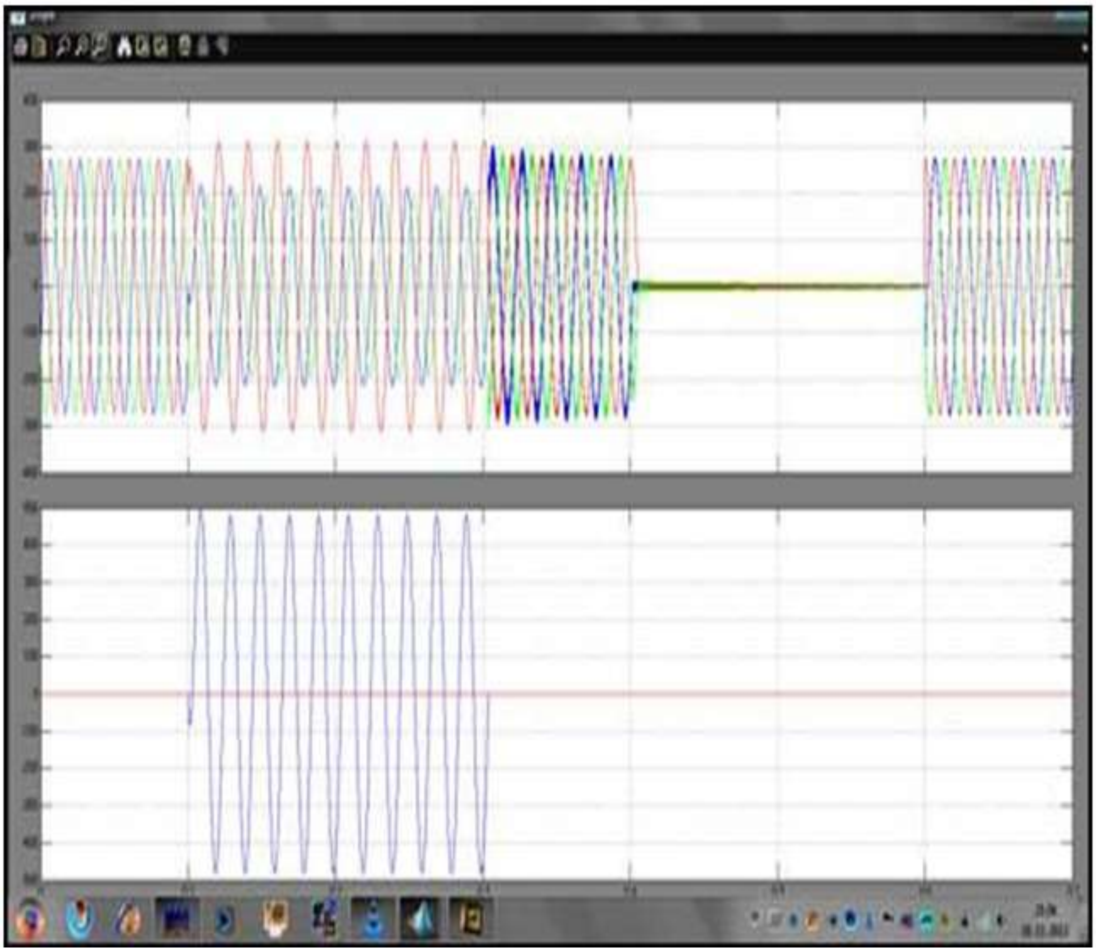

**Fig. 9 :** Output leakage current at the ground

The transmission line is implemented with single phase grid and two loads. The regulator and rectifier are connected in series to identify the overload of current. By using the thyristor switch the device is prevented by turn off the circuit.

## III. CONCLUSION AND FUTURE ENHANCEMENT

A monitoring scheme for substation safety assessment is proposed, which periodically measures the voltage and current with a preset frequency and effectively evaluates the grounding grid conditions with the help of a data-base. The test current is generated by firing a pair of thyristor. The generation and injection of testing current signal is carried out. Then the sequential measurement of voltage and current value indicates the grounding grid condition. Thus the presence of rusted rods or any other faults can be easily identified. The ground potential is reduced inside and outside the substation during a short-circuit event. The overloading problem is overcome by continuously monitoring the line voltage with the thresholdvalue.

The sensors network can be installed at various locations of substation. These sensors should be connected to a central database where an evaluation process is carried out by comparing the newly measured database where an evaluation process is carried out by comparing the newly measured data to the limits from IEEE standard, or checking if the data variation at the same spot exceeds safety thresholds. It could be used to locate broken section or missing grounding electrode based on the step/touch voltage profile obtained from the sensors.

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