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SMART PROTECTION SYSTEM FOR DISTRIBUTED ENERGY RESOURCES (DER)

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ABSTRACT

The present world is marching towards renewable energy resources for the power production. Under this consideration, Distributed Energy Resources (DER) plays a vital role in many aspects. Though it has many benefits, it is familiar for its small scale of power generation and loss less distribution. But the protection system in Distributed Energy Resources is still a challenging task. Therefore this paper is proposed to provide a smart protection system for the distributed energy resources. The module in this paper use basic microcontrollers for sensing the electrical parameters, isolating the faulty area and also to communicate the fault events occurring in the Distributed Energy Resources. This protection system also records the events happening in the DER and a log is maintained for the future reference. These data can also be uploaded to a web server for monitoring.

Keywords: distributed energy resources (DER), faults, protection system

INTRODUCTION

The present world is switching to the natural resources for the power production to reduce pollution, high economy of power production through non-renewable resources, large structures of power plants, etc. Hence the concept of distributed generation is introduced to overcome the disadvantages of power production by non-renewable resources such as coal, natural gas & oil, uranium, plutonium, etc.

Distributed Energy Resources

The Distributed Energy Resources (DER) is the small scale units of power generation that operates locally and also connected to the major power grid at the distribution level. It has two types of operations namely,

1. Islanded mode operation and
2. Grid connected mode operation.

The islanded mode of operation is the operation in which the DER is locally connected to the loads directly and is not connected to the major utility grid. The grid connected mode is the operation in which the DER is connected to the major utility grid and supplies the surplus of power generation from the DER to the major utility grid. The power generation from the DER is considered as excess only after it satisfies the local demand. This DER has enormous advantages in the power generation when compared to the large scale power generation. Though it has many benefits, it has a remarkable merit of reduced power losses. This merit is due to the synchronization of DER to the distribution level grid but not to the transmission grid.

But synchronization of power generated from the distributed energy resources to the major utility grid is quite harder. It has some lack in advancements regarding the protection systems and the communication of the fault events occurring in the DER. Therefore the module in this paper is to provide a reliable protection and communication system for distributed energy resources (DER). The main protection issues associated with the connecting of DERs to the distribution network includes Blinding of Protection, false sympathetic tripping, reclosure-fuse mis-coordination, lapse of inter fuse coordination and failed auto-reclosing.

WORKING PROCESS OF THE PROPOSED MODULE

This protection system is designed to provide protection against the following parameters,

- Over voltage and under voltage variations
- Short circuit currents
- Theft current
- Frequency fluxuations and
- Phase sequence variations between 3-phases.

BLOCK DIAGRAM

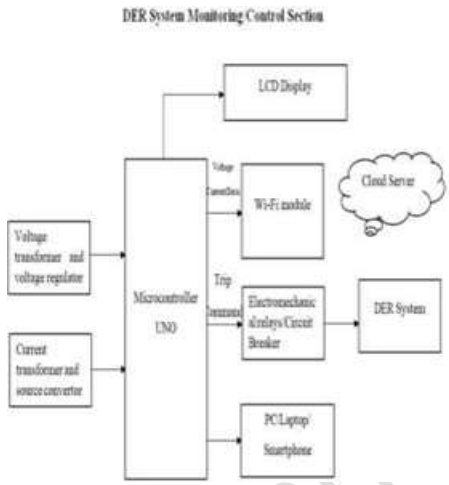
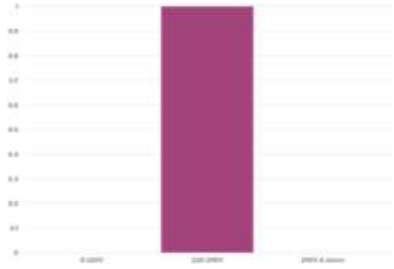


Figure-1 Block diagram of the proposed module

Voltage sensing and protection for over and under voltage:

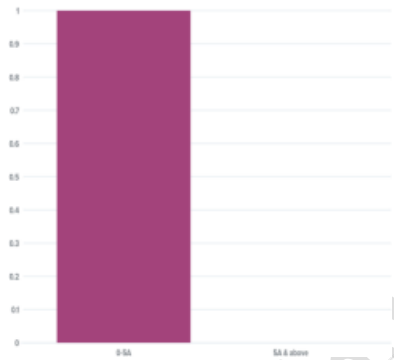
This circuit is designed to monitor the supply voltage. The supply voltage that has to be monitor is stepped down by the potential transformer. Usually the step-down transformer 0-6v is used as the potential transformer. The potential transformer is followed by the voltage regulator circuit which delivers a constant desired output at a range of 5v to the microcontroller at which the microcontroller operates. The supply voltage is sensed by the microcontroller by verifying it for the prescribed value which is feed in the program. If any variations from the prescribed values are sensed by the microcontroller, it generates a trip command to the relays and trips the supply. It also generates a message to communicate the owner about the fault through IoT.



The above graph represents the output supply acording to the output voltage of the power supply.

Current sensing and protection against short circuit current:

This circuit is designed to monitor the current range of the supply. The supply current that has to monitor is step down by the current transformer. The step down current is converted from the current source to the voltage source with the help of shunt resistor since the microcontroller works based on voltage source. The further operation is similar to the voltage protection system. The trip command is generated for exceeding of the current range beyond the set maximum demand value in the program. The communication of this fault is similar in all sorts of faults occurring in Distributed Energy Resources.



This is the graphical representation of supply condition respective to the output current Ranges.

Frequency fluxuations:

The frequency of the generated power supply is monitored from the analog signal of the voltage waveforms. Indian frequency range is 50Hz and this value is uploaded in the program for monitoring. If the microcontroller senses the generated power supply of any other frequencies, it trips the supply.

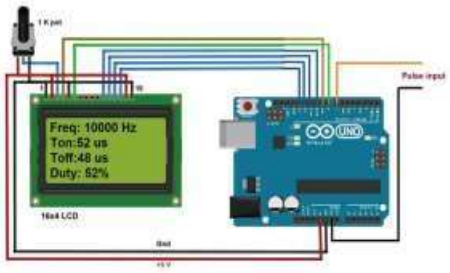
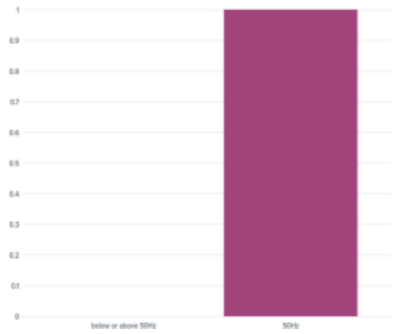


Figure-2 Arduino connected to LCD with frequency measurement



Graphical representation of output supply respective to thefrequency

Power theft:

The theft current is repudiated by uploading the number of output tapings. Usually the distributed generation in low ranges has only two output tapings; one is for the domestic or household distribution and other for connecting to the common grid. So by prescribing the number of output tapings and the appropriate distance of the taping from where it is drawn are prescribed in the microcontroller. If the microcontroller senses current drawn from any other point it detects it as power theft and trips the output power supply. The microcontroller also locates the exact point of the illegal current taping drawn from the output. This is similar to the method of locating the fault or breakage in the underground cables.

There is another method of protecting the power supply from the power theft. In this method current transformers are connected at both the nodes (output node and the node where it is to be connected to the common grid) of the DER. Similar to the voltage and current monitoring, the current ranges in the current transforms of both nodes are continuously monitored and compared by the microcontroller. In the microcontroller it is defined that the readings in both the current transformers must be more or less equal. If any huge mis-match in those readings is detected by the microcontroller then it indicates that, there occurs the power theft. Therefore the microcontroller trips the output power supply.

Phase sequence variations between three phases:

As it is known already that phase sequence is one of the three important parameters to be monitored and unified before synchronizing two power supplies, this protection is necessary. In this protection an additional meter called phase angle detector is essential.

This phase angle detector is connected between two phase of the output power supply (R phase-Y phase, Y phase –B phase, B phase -R phase). By this the phase detector continuously detects the phase angle difference between the two phases. The display of the phase detector is connected to the microcontroller through regulating components. The microcontroller senses the readings and records the readings. The prescribed value of phase angle between the two phases of the power supply is always 120 degree. Therefore this prescribed value is feed to the microcontroller to be monitored. If the microcontroller reads any value other than the prescribed value in the phase detector, it trips the output power supply.

Similar to the frequency, phase sequence also can be monitored from the analog signals of voltage and current. But the above mentioned is more effective for monitoring the phase sequence between the power supplies.

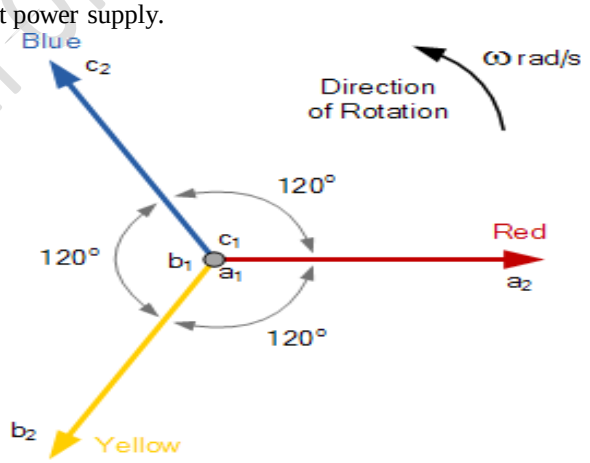
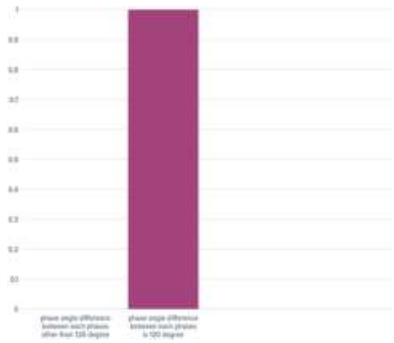


Figure-3 Vector diagram of the current state of balance



Graphical representation of output supply respective to the phase angle between the phases

MERITS OF SMART PROTECTION SYSTEMS:

1. Protection is very reliable.
2. Improved communication method.
3. Low cost of installation and need of no maintenance.
4. Usage of IoT the person who own the DER can monitor the electrical parameters of the supply wherever he/she can
5. Web server maintenance helps the owner to maintain the record of fault events in the DER.
6. All these advantages promote the distributed generation to run in grid connected mode safely.
7. By this protection system, the faults can be detected immediately and so it can be cleared then and there.
8. Consumer out stages can be reduced.

CONCLUSION

Therefore the above proposed system provides an outline of smart protections for DER against faults. These are the major faults occurring in DER. Hence in the above proposed article, those five parameters have been sensed and the protection is given against them (i.e.) voltage faults and short circuit current faults, theft current etc... Other than this, with the help of the microcontroller all the electrical parameters such as the parameters which numerical relay monitors in the high tension bus bars can be monitors.

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