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Automatic Grid Healing System Using Minimum Spanning Tree Algorithm

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ABSTRACT

Today's life is totally dependent on electrical power supply and in some cases the maintenance at power generation stations or failure of nodes due to natural or manmade calamity causes hurdles in maintaining electric power supply at each node. To overcome such drawbacks selfhealing techniques are used. Self-healing is the characteristic which helps any system to recover itself to the normal level whenever a fault or breakdown occurs in the system with or even no human intervention. In the proposed self-healing grid system, the cost-effective prim's minimum spanning tree algorithm is introduced to avoid problems of power failure due to link failures in power grid networks. The Fault location, Isolation and Service Restoration (FLISR) solution is based on Prim's algorithm. To support Prim's algorithm, simulation is carried out using MATLAB software. The system will enable to find the minimum spanning tree cost of the link to the different nodes in the electric grid network. It will also provide a path to connect all the nodes in the electric grid network even after failure occurs in between links. The proposed system can perform the FLISR process as quickly as within several seconds of computation time and the system is stable and can handle complex scenarios such as multiple simultaneous faults.

Keywords—Self-healing, grid system, Prim's algorithm, minimum spanning tree, FLISR, MATLAB.

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I. INTRODUCTION

Traditionally, electricity is supplied by power plants by means of a grid. A network of power lines & subtractions that carry electricity from power plants to homes and industries. Today, the grid has problems. It needs updating & is running at its full capacity. When the power lines break or power plants cannot produce enough power, blackouts can occur. The traditional grid makes electricity management difficult. To overcome this situation, a selfhealing smart grid is introduced. Self-healing grid is obtained by adding sensors to the existing grid. In case of a line failure, the sensors will detect the failure thereby allowing the controller to another path to supply electricity to the required stations by excluding the failed link. Routing the power around the failed link can be done using the minimum spanning tree algorithm. Thus, a smart grid based on this minimum spanning tree algorithm will limit the rate of blackouts & also help in managing the cost of power supplied during peak & other hours of the day.

II. LITERATURE SURVEY

The electrical infrastructure is over burdened & again quickly. This is leading to network challenges. Each year power disruptions are costing the world's economy thousands & millions of dollars. There is a waste in the way power is delivered. This grid doesn't know the power demanded by the consumers resulting in increase in cost & decrease in efficiency of power delivery. The development of smart grid is the infusion of the electrical infrastructure with the grid efficiency software in the distribution substations and station thereby making it more reliable and efficient

[1] IEEE PAPER (2010): - SMART GRID- A RELIABILITY PERSPECTIVE.
Authors: - Khosrow Moslehi, Ranjit Kumar -The reliability challenges are faced by the grid during its practical execution due to grid congestion, uncertainty in energy distribution due to environmental or sustainability factors -

These challenges were overcome by designing and infrastructure provided monitoring and control of grid.

[2] IEEE PAPER (2011): - PLANT OPERATION AND CONTROL WITHIN SMART GRID
Authors: - Subrata Mukhopadhyay, Sushil K. Soonee, Ravindra Joshi-SCADA (Supervisory Control and Data Acquisition) System with EMS are used to properly monitor and control the grid -However disturbances in certain regions could not be avoided. Thus PMU (Phase Management Unit) was installed for security of larger grids

[3] IEEE PAPER (2012): - A CONTROL STRATEGY TO FAST RELIVE OVERLOAD IN A SELF – HEALING SMART GRID
Authors: - Zaibin Jiao, Kun Men, Jin Zhong
-Overload is the main issue faced by the grid -The grid is simplified by WAM – based nodal analysis and control variables are calculated

[4] IEEE PAPER (2012): - STRATEGY & COORDINATED DEVELOPMENT OF STRONG & SMART GRID
Authors: - Xiaoling Jin, Yibin Zhang, Xue Wang -The overall issue of the smart gird is analyzed by studying all four sides
1) co-ordination of physical power grid & smart technology application
2)co-ordination of smart grid & emerging industry
3)co-ordination of upgrading technology & management
4)co-ordinated development among generation, distribution, consumption & dispatching

[5] IEEE PAPER (2013): -TOWARDS A CONSTRAINT BASED APPROACH FOR SELF HEALING SMART GRIDS
Authors: - Vasileios Koutsoumpas, Pragya Gupta-The most important functional requirement i.e. balanced between consumption and production of power-This is achieved by evaluating different smart grid system within german smart grid system in which six model regions developed individual smart grid solutions.

[6] IEEE PAPER (2014): -SMART GRID CONCEPTS APPLIED TO SELF HEALING IN DISTRIBUTION SYSTEM
Authors: - D.P. Bernardon, L.N. Canha, V.J. Garlia, G.S. Lopes
-Self healing plays an important role in reducing the time required to restore an energy supply. -This paper presented a methodology developed for automatic power restoration system which operates remote control switches in the distribution network.

[7] IEEE PAPER (2014): - MULTIAGENT BASED DISTRIBUTION AUTOMATION SOLUTION FOR SELF HEALING GRIDS.
Authors: - Markus Eriksson, Arshad Salim, Oleg O. Vasilenko
-The FLISR (Fault Location Isolation & Service Rstoration) problem was fixed to an extent by using distributed adaption of prims algorithm to support implementation of MAS in smart grid.

[8] IEEE PAPER (2015): -CONSIDERATIONS ON SELF HEALING AND ASSISTED HEALING FOR POER TRANSMISSION SYSTEM IN OPERATION CENTERS.
Authors: -Fabio A.S. Antunes, Paulo F. Riberio

-Self healing aims at avoiding or minimizing load outags in power transmission system. This is desigined through highly integrated software to EMS. The operational procedure is structured in metadata format so that, any new operating procedure are automatically absorbed into self healing system.

[9] IEEE PAPER (2016): - DEVELPOMENT OF A SELF HEALING STRATEGY WITH MULTIAGENT SYSTEMS FOR DISTRIBUTION NETWORKS
Authors: - Jonatas Boas Leite, Jose Robelto
-IEC 61850 standard is used as agent communication protocol to improve the switching operation in the smart grid.
-The switching of local agent isolates the fault as well as is aware of the whole network distribution.

All the above IEEE papers have proposed a self healing grid system based on an IT architecture thereby increasing its reliability coordination overload relief etc. The propose system will implement the grid system in lined with system proposed in the mentioned IEEE papers, in the form of a single board computing systems for the minimum spanning tree algorithm but with better algorithmic changes like - modified fault location, isolation and service restoration (FLISR) strategy.-The proposed algorithm will perform the FLISR process quickly keeping the system stable and also handle complex scenarios such as multiple simultaneous faults.

III. IMPLEMENTATION METHODOLOGY AND SIMULATION

A. Methodology
The design of the system has to be created taking into consideration that it has to overcome insufficiency of any system. So cost effective grid management system has to be designed in a manner that it resolves the problem due to power failure but also find the minimum spanning tree cost for routing the self-healing concept MATLAB is used. The controller is accessed by the computer through TTL cable using serial protocol and desktop using MATLAB. The controller has to be programmed through IDE for UART reception to relay driver ULN 2003 and then controller is connected to the USB 2.0 port. The connection of LED and power supply for the gridding system using relays which are controlled by ATMEGA328P.
If any link in designed system fails then the MATLAB section is aware of it and it gives the newly calculated prim's algorithm variable and sends it to the controller at 9600 baud rate. The controller receives the variable and turns on a specific pin related to a specific relay and pulls up

that respective pin connection through that relay and it is connected.

The steps of a working hardware connections are as follows: -

-Create initial variable for the algorithm resources in python language.

- Take input from the user for interaction with code.

-Take fault condition from the switches using GPLD package for python language.

-Update variable into the code.

-Find out the minimum spanning tree cost. -Send code words to ATMEGA328P using COM port at 9600 baud rate.

-Drive the relay according the code words received at ATMEGA328P serial port.

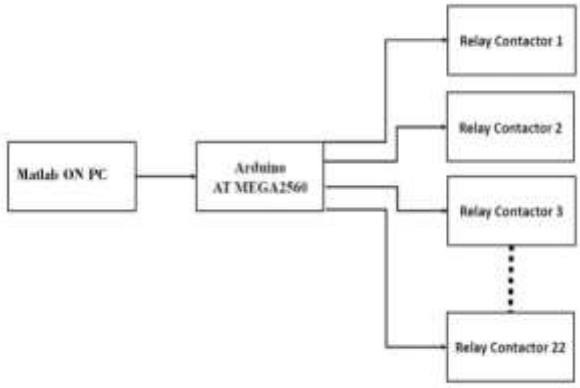

Fig. 1. MATLAB and Arduino based automatic grid optimization system

B. Working Principle

1. MATLAB Section:

In the MATLAB section nodes are connected to each other using the links present. Nodes are powered through the power supply. If any of the one links fails due to some natural or manmade crisis, then the system is designed to recover the failed node which is connected to the failed link. The cost of developing spanning tree should have the minimum cost when prim's is calculated. If a node fails then the node connected to that node will also fail due to power distributions & not due to link failure. This should be taken into consideration effectively recover the failed node so that the system goes through the prim's algorithm that will calculate the systems recoverable capability & enhance the grid

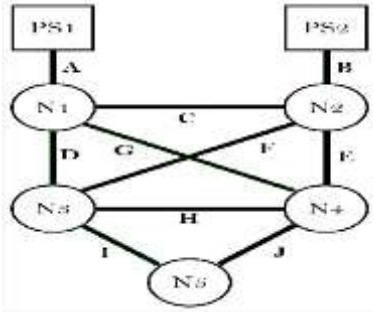

Fig.2. Node connections in MATLAB

2. Arduino and Driving Section:

In active mode, if any node fails then MATLAB system recalculates the minimum spanning tree for the system & also calculates the substitute connection for failed node. After calculating the minimum spanning tree algorithm, the failed node is corrected to the new power source by using node connection switch. After this process, manual process is used to recover the failed node and when the problem is solved by the repairmen then the system returns to its default connection. In this process, Arduino acts as a receiver of command from MATLAB section and driver for relay contacts for each link present in the grid.

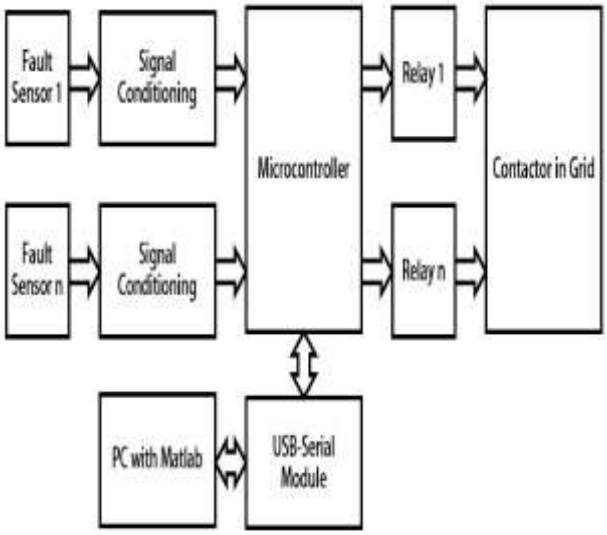

Fig. 3. Block Diagram of MATLAB and Arduino Based Automatic Grid Optimization System

C. System Execution:

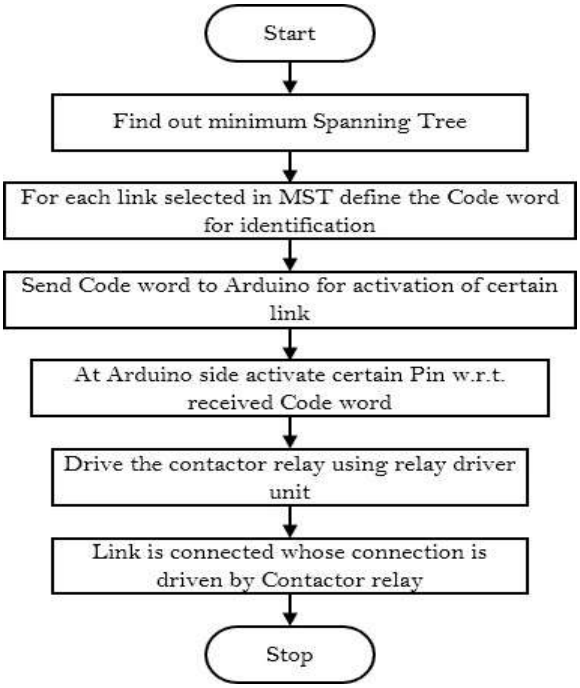

Fig.4. Flowchart of the process

System Initialization: At this step, all the components of the system will start. System will check all the components for its status. If any component fails, then system will correct that error or notify the user about component failure. If there is no such failure then system goes online and starts working. Following operations take place in this stage:

- All relay contactors are in off status.
- GUI application on monitor.
- Program takes the number of user input and send it to system.

Calculate minimum spanning tree: At this stage, code running behind GUI takes the action of finding minimum spanning tree with the given input by user which is changing with time. After that the code word will be sent to Arduino for each link to be connected in grid.

Code word parsing: Code word we got from the last stage does not have that many details about which link to activate in the grid. Arduino does this for us in this step. Arduino receives the code word and using look up table it activates relay contactors accordingly through the relay driver, so we have to perform actual operation of creating optimized gridding system here.

- Parsing Code word.
- Signaling to relay driver.

Activate link: After above process, relay driver sends a signal about which link should be activated at that certain point. It activates the relay contactors. By the end of all code words received we get the optimized gridding system based on weighted link.

D.TEST AND RESULTS

Initially we have designed a code for finding the minimum spanning tree algorithm and link activation in MATLAB. Below are the simulation results of our project:

STEP I:

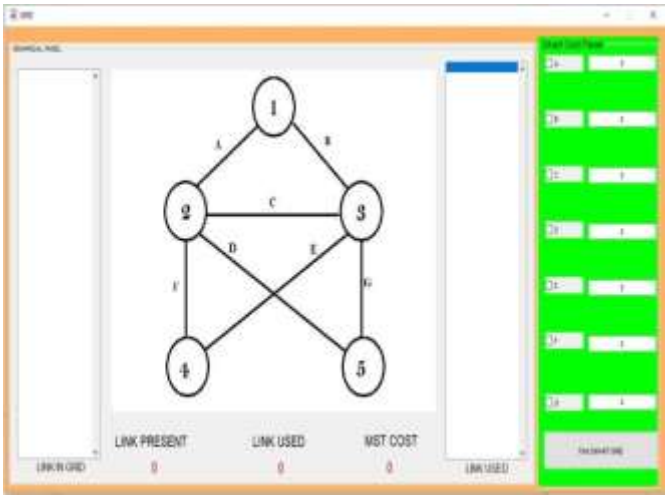

Fig.5.GUI Window

STEP II:

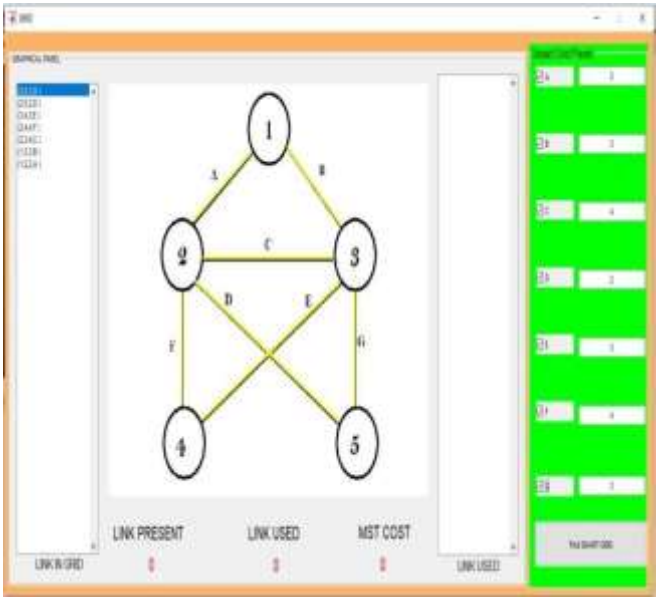

Fig.6.Parameter settings, link selection and link weightage

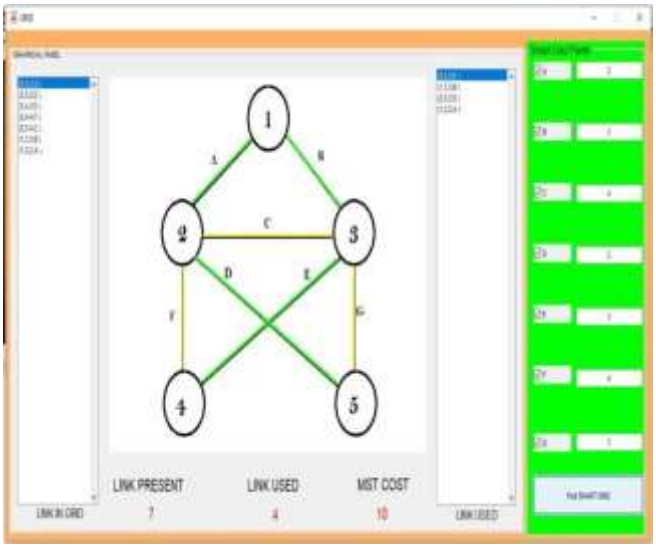

Fig.7.Simulation Output

IV. DISCUSSION AND CONCLUSION

This simulation concludes that using Prim's algorithm, the traditionally running electricity grid system can improve the overall efficiency of the gridding algorithm in which each node can heal itself using online

V. REFERENCES

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