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A Complete Restoration Methodology using Virtual Instrumentation

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ABSTRACT

Today's world depends upon the reliable electrical power. But due to some reasons people did not get reliable power. Currently in power system companies use various methodologies are used to restore the power system. This paper making the Virtual instrumentation model for monitoring the power system, estimate the system state and controlling power system outage by using virtual instrumentation and DAQ tools. This paper simulates the IEEE 39 bus power system and the result shows the system performance for different states.

Keywords: Restoration, Blackout, Black start, Non Black start, State Estimation.

1. INTRODUCTION

A power outage is a short term or long term power loss to an area. Power outage classifies as different manner like blackout, brownout and power failure. Blackout is a long term power failure outage may be taken few minute or few weak. It mainly happened for natural disaster, overloading, fault at power station and substation. Brownout is a dimming experience of all electrical equipment due to voltage sag. It mainly happened for interruption.

Power failure is affect the critical load as hospital, mine, sewage plant, traffic signal, electric train, telecommunication and etc. It affects people regular life pattern. So whenever power outage is occurring power restoration will be execute as soon as possible. All critical loads should be having some emergency power like standby generators and array of lead acid batteries.

Power generation and demand should be equal in every second or otherwise it cause the overloading the system so it affect the power system. Power system failure will be affect the neighboring grid that is called cascading failure.so it affect the main grid. This is the way blackout will be form in the power system. Power restoring after an extensive area outage is difficult to restore. Whenever fault occur it will isolated by healthy grid. Then faulty grid restores power by healthy grid and also it meets the demand. Power system separate by island. Normally in each island have one Black-start unit, it restore the power in the individual island. Then it will synchronize together.

Proposed Virtual instrumentation system

In VI model collect the data from the power system as Power generation, power demand, voltage level and frequency level. Then it has compare with all constrain. It estimates the state of the system. Power system VI model checks equality constraint and inequality constraint. Equality constrained focus balanced power generation load and demand. Inequality constraint focuses violation of frequency and voltage level. At normal state all the constrained should be satisfied. At alert state Equality constrained would be violated, in that it alerts the operators to recover to normal state. At Emergency state inequality constraint would be violated, it

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recover the system as soon as possible, if it is recovered at the certain time it affect the neighbor system might be blackout would be happened. At this state it acts as restorative state.

In restorative state begin the generator startup strategy for recover the power system. IEEE 39 bus system having 9 NBS (Non-Blackstart generators) and 1 BS (Black start generators). Black start generators don't need cranking power; it will start without external power like hydro power plant etc. Black start generator providing cranking power to Non-Black start generators.

Table 1 consists of time taken for restoration action done in the system. In the system there are so many buses, tie line, BSU & NBSU and each will take different time for restoration purpose. Table 1 contains the data with corresponding time taken for restoration action. Table 2 consists of the bus path From Black start generation unit G10 to Non Black start generation units present in that bus system.

Table 1
Transmission path for BS to NBS

S. No.	*Black start*	*Non Black start*	*Transmission path*
1	G10	G1	BUS : 30 – 2 – 1 – 39
2	G10	G2	BUS : 30 – 2 – 3 – 4 – 5 – 6 - 31
3	G10	G3	BUS : 30 – 2 – 3 – 4 – 14 -13 – 10 – 32
4	G10	G4	BUS : 30 – 2 – 3 – 18 – 17 – 16 – 19 - 33
5	G10	G5	BUS : 30 – 2 – 3 – 18 – 17 – 16 – 19 – 20 -34
6	G10	G6	BUS : 30 – 2 – 3 – 18 – 17 – 16 – 21 – 22 -25
7	G10	G7	BUS : 30 – 2 – 3 – 18 – 17 – 16 – 21 – 22 -23 – 36
8	G10	G8	BUS : 30 – 2 – 25 – 37
9	G10	G9	BUS : 30 – 2 – 25 – 26 – 29 – 28

Table 2
Restoration action

S. No.	*Restoration Action*	*Time (min)*
1	Restart BSU	15
2	Energize busbar from BSU unit	5
3	Connect Tie line	25
4	Crank a NBSU from a Busbar	15
5	Synchronize between busbar/line	20
6	Pick up load	10

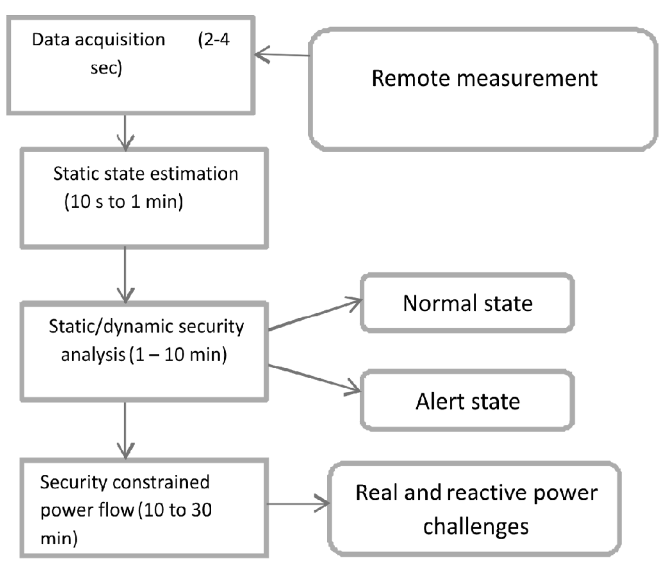

Figure 1: Flow chart

2. VIRTUAL INSTRUMENTATION (BLOCK DIAGRAM)

Virtual instrumentation Block diagram is shown in the figure, it have controller and indicator as per graphical programming flow. Inputs are getting from integer controller as Generation power, demand power, frequency and voltage. Based on these inputs the respective state will be occurring.

If Pg = Pd then the state of the system is normal State, In this state all the constraint values are in respective values.

If Pd is greater than Pg, Then the system Will go to Alert State due to increase in demand power on the Load Side

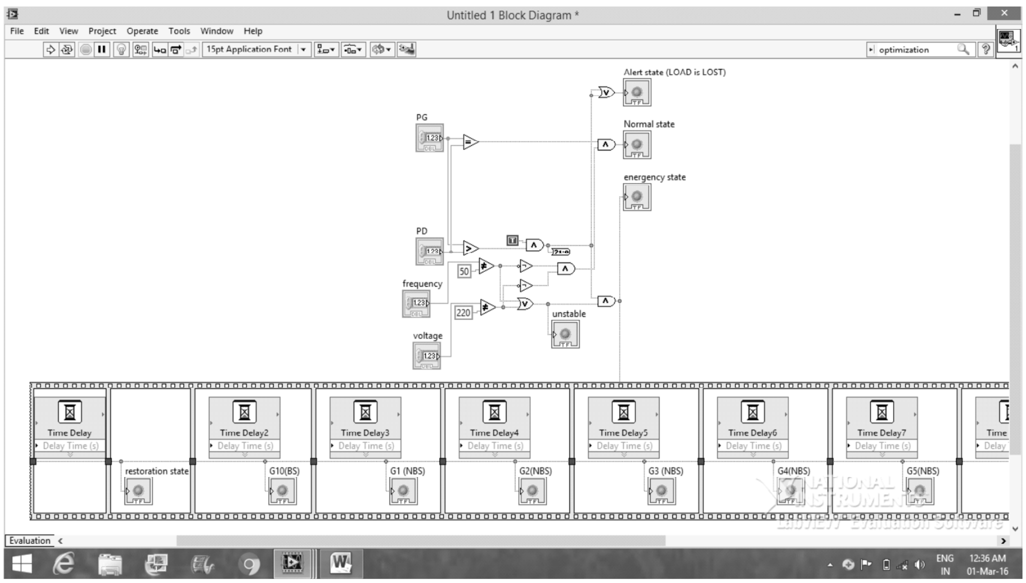

Figure 2: VI Model for Power system state estimator and controller

If pg, pd and either of V & F constraints are Violated their respective Values Then the Emergency State will Occur, If these Varied Constraints are Not rectified then After a time delay Set by user the system will go into restoration State

3. VIRTUAL INSTRUMENTATION (FRONT PANEL)

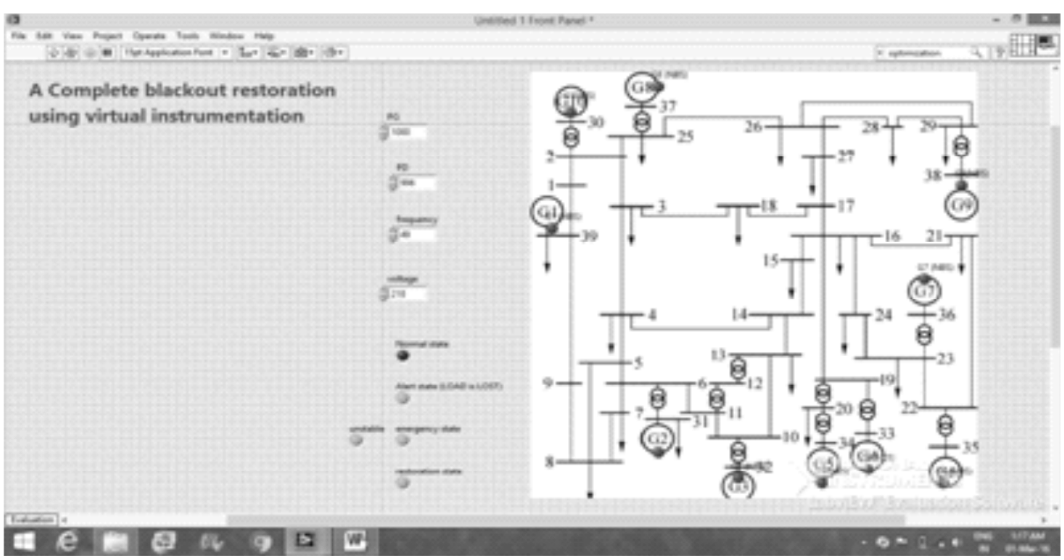

Figure 3: VI Model for Power system state estimator and controller

The Front Panel Consist of a 39 Bus System along with 10 generating Stations and it also consists of the input indicators and output indicators, The Input indicators are generation power, demand power, Voltage and Frequency. The output indicators are Booleans each Boolean will indicate each state I.e. Normal State, Alert State, Emergency State and Restoration State. Whenever Input parameters are varied thus corresponding State Boolean will be turning on.

If the System Goes to restoration state then the system will be restored automatically that will be done By starting each power plant by using black Start power plant G10.

I.e.G10 will give cranking power to start the plants G1,G2,G3,G4,G5,G6,G7,G8 & G9, Like this the 39 bus System is restored.

4. SIMULATION RESULT

4.1. Normal State

In this balanced generation and demand power, voltage and frequency values are not violating their desired values, hence the state of the System is Normal State thus the normal state Boolean will be turning on

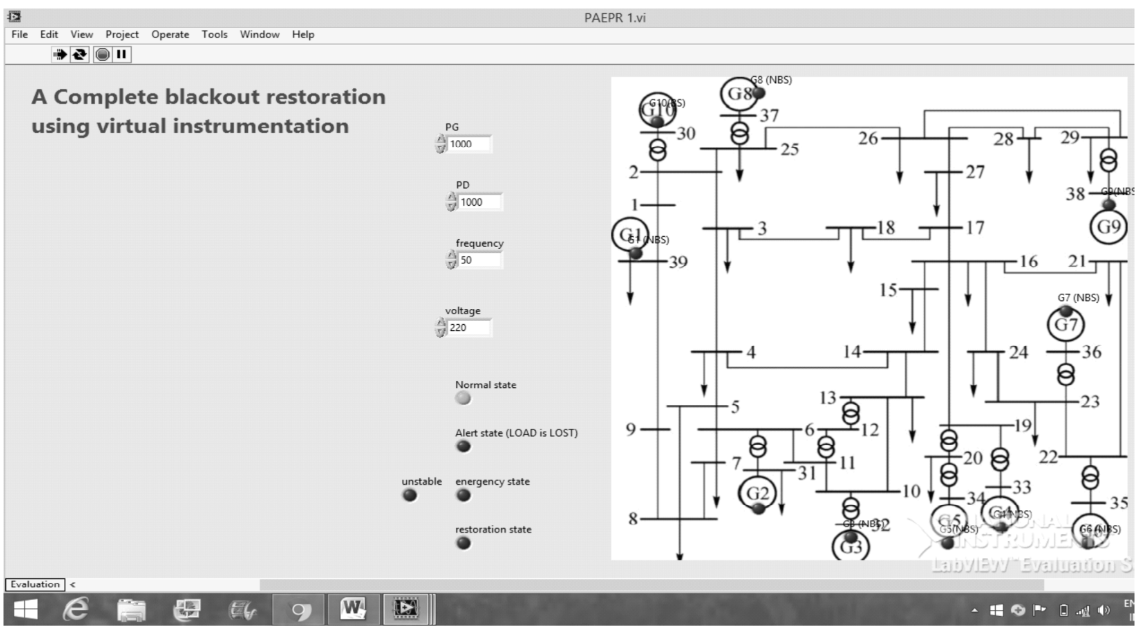

Figure 4 : Normal state result

4.2 Alert State If unbalanced generation and demand power, then the system will go in to alert state, thus the alert state Boolean will be turning on. In alert state it alert the system operators.

4.3. Emergency State

If unbalanced generation and demand power and Either of Voltage &Frequency Violates their respective desired values then the system will go into Emergency State, thus the emergency state Boolean will be turning on, In this system operators balanced the system load.

4.4. Restoration State

During Emergency State if the Violated Parameters are not rectified then the System will go in to restoration state after some time this time delay will be set by user.The restoration state Boolean will be turning on.

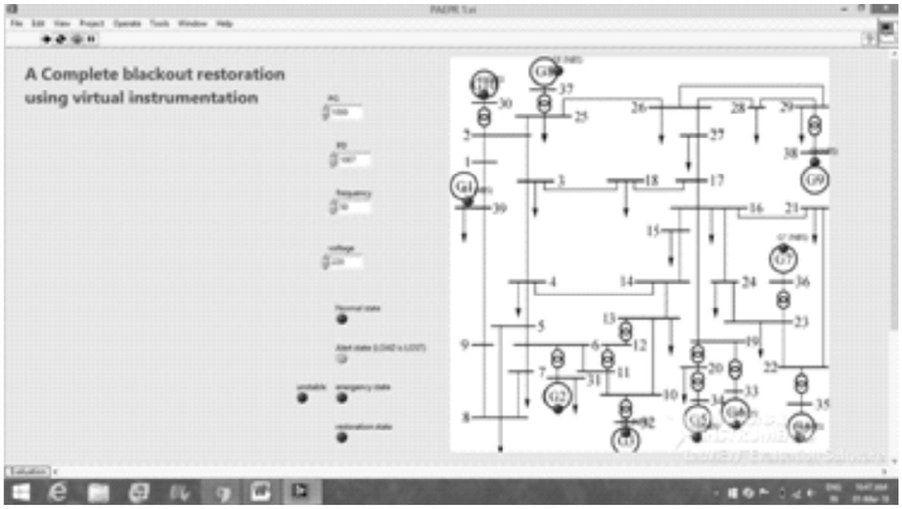

Figure 5: Alert state

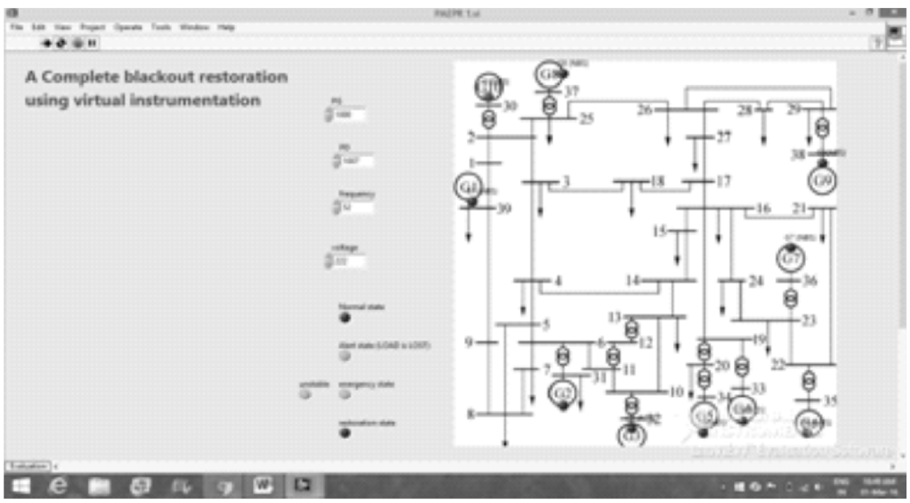

Figure 6: Emergency state

In the below front panel we can see that all the power plants except G10 are in off position Since G10 is a blackStart power plant.

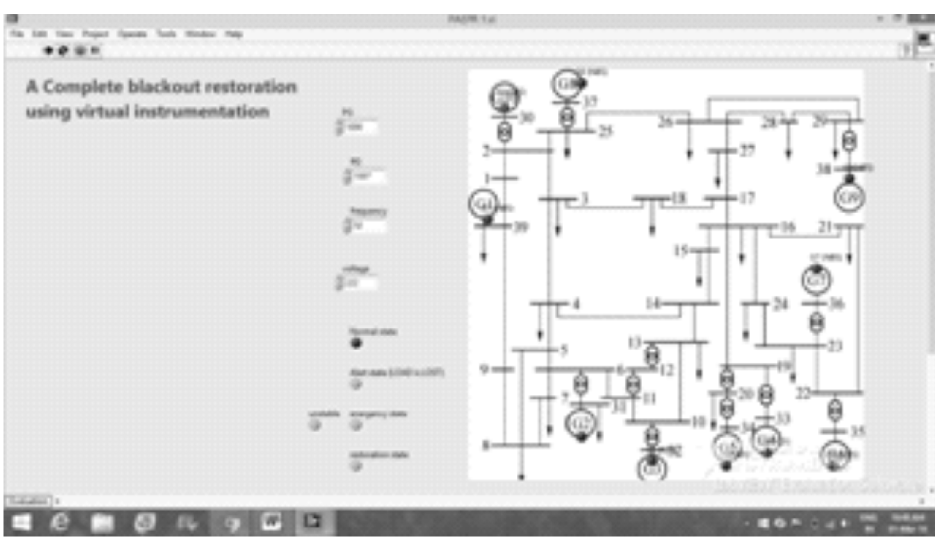

Figure 7: Restorative state

The black Start power plant will be turning on the remaining power plants connected in that system, in this way the power system will be restored automatically.

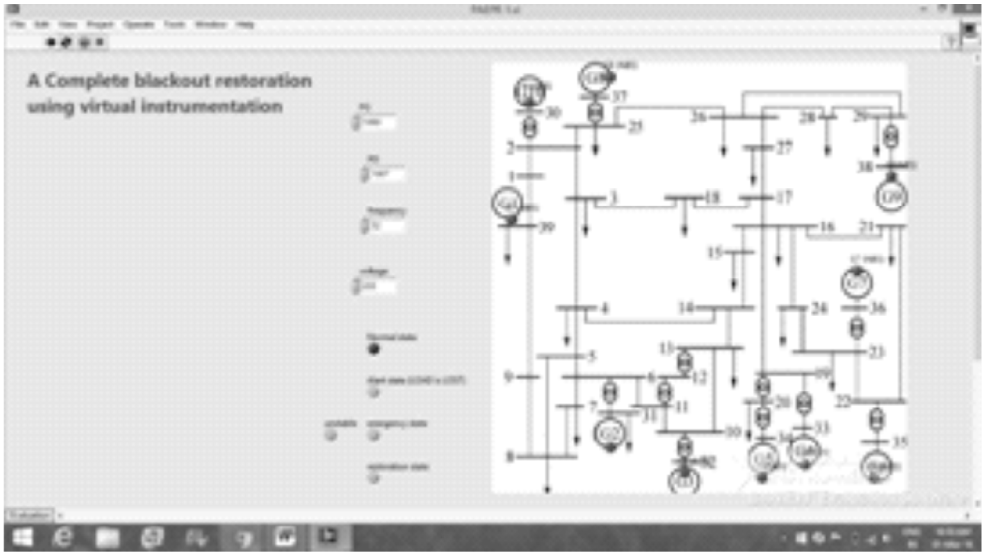

Figure 8: Complete restoration state

5. FUTURE SCOPE

This unit takes much time to restore the system. In future artificial intelligence implemented virtual instrumentation to control the power system blackout for fast response.

6. CONCLUSION

Power system analysis restoration implemented by virtual instrumentation using LabVIEW. Here it monitors the data & shows the states of the systems. If it is blackout condition the system start up the black start generating unit by black start units. It shows & displays the different output States

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