MICRO GRID STUDIES DUE TO FAULT OCCURRENCE USING IMMUNITY TECHNIQUE

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ABSTRACT

In this paper, micro grids resulted due to transient fault occurrence are studied utilizing Artificial Immunity System (AIS). Transient fault detection is analyzed, studied and protected using the concept of wide area measuring, protection and control (WAMPAC). WAMPAC gives the opportunity of having a wide information system and sending selected local information to remote locations. The existence of Phasor Measurement Unit (PMU) overcomes the problem of real time monitoring problem and it help to put a defiance strategy which is designed to answers the following inquiries: a- detecting abnormal condition, b- taking Special Protection Schemes (SPS) action, c- initiating SPS action, and d- taking SPS action in certain place. The technique is based on a technology called Artificial Immunity system (AIS). It is used as a predictor to decide if the system is stable or not, and determines the main generating groups which can construct proper operating islands. The proposed system is applied on New England IEEE 39 – Bus system. The proposed defensive approach shows accepted results in mitigating the power system transient instabilities.

KEY WORDS

Micro grid, Artificial Immnity System (AIS) , Power Systems Analysis Framework (PSAF), Wide Area Measurement Protection And Control (WAMPAC) , Phasor Measurement Unit (PMU).

1. Introduction

Due to the increase in electrical power demand every period of time, very complex systems have been built to satisfy this increasing demand. To build successful power system, engineers must succeed on achieving two main goals; reliable and uninterrupted service to the loads. In order to execute goal of reliable system we need [1];

1- Keeping synchronous generators running in parallel and with adequate capacity to meet the load demand.

2- Reliable electrical service is to maintain the integrity of the power network if anything go wrong with the transmission line or any part of the network this may influence flow of power to the load .This usually requires a study of large geographical areas since almost all power systems are interconnected with neighboring systems [1].

It is very important to study any fault causes system contrary to reliable system, through this large geographical area in synchronized behavior. Global system, phasor measurement unit are the most important technology to achieve synchronism in wide area electrical power system.

For the last few decades, tremendous success occurs in the measurement techniques. A huge monitoring system was established. A huge projects start to be held by the help of the rapid changes in the monitoring technology. The electrical power tie between Egypt and different country to get benefit of electricity is an example of these huge projects. It becomes necessary to build a system that can monitor, detect and take fast action without affect the whole network.

The use of phasor technology started in the 80's with the early pioneering work done by Bonneville Power Administration [2]. The Eastern USA Interconnection blackout of August 2003, highlighted the need for technologies that provide wide-area studies, analysis and monitoring [2]. Real time dynamics monitoring and time-synchronized data became accepted by the industry since that blackout. Researches in Phasor Measurement Unit (PMU) spread and started to be applied in industry. Examples of PMU applications are protection and control, dynamics of the system, early alarming, disturbance analysis, and monitoring and visualization. Wide Area Measuring, Protection And Control (WAMPAC) revolution follows the progress of PMU technology. WAMPAC allows the propagation mitigation of the major disturbances in the power system and taking an action called Special Protection Schemes (SPS). As a result of this technology, the researchers try to develop new approaches that can achieve the concept of ideal system.

Artificial intelligent is said to be started at ancient Egypt [3], but the first time the expression appear on 1956 at the Dartmouth conference. It expanded due to theories and principles developed by its dedicated researchers. In

1950 the connection between human intelligent and computer as a machine, that save time, was started. The early AI program was designed by Newell and Simon it called *The Logic Theorist*. It passed on the idea of represent any problem as tree model and try to choose the branch that give best solution [3]. As time pass, new ways appear, trying to simulate natural systems, to approach solutions for existing problem one of these systems is immunity technique.

In the mid 1986 the artificial immunity system stared with the farmer Packard and Perelson's [3] .It considers a new area of bio-inspired computing [4]. The first paper that has immunity on its title was published on 1994. It was published by Forrest *et al* and Kephart .As the growth of work on this method, the International Conference on Artificial Immune Systems ICARIS conference series was started in 2002 and continues to operate. This is the best source of reference material to be read, in order to collect the variety of application areas of AIS. AIS is moving into an area of true interdisciplinary and one of genuine interaction between immunology, mathematics and engineering [5].

In this paper, the concept of wide area measuring, protection and control (WAMPAC) is used .The measurement principle is going to be applied using phasor measurement unit, while control principle is applied by utilizing new artificial immunity system technique. Protection concept appears obviously in separating generator into islands depending on case study.

2. Power System Analysis

As the stability is important factor for the synchronous machine and (consequently to the power system), so differentiation between sudden and major changes, smaller and more normal random impacts is necessary.

When transient stability problem occurs such as the loss of a major generating unit the synchronous machines may lose synchronism. The stability of the machines will be determined by many factors, including the power-angle curve. It is sometimes incorrect to consider a single power-angle curve, since modern exciters will change the operating curve during the period under study.

During transient time a lot of changes take place affecting the machine terminal voltage, rotor angle, and frequency. It depends upon the network impedance as well as the machine parameters. As a result the machine output power will be affected .The power angle equation is set with adding the effect of saliency [6].

$$P_e = \frac{EV}{X_d^{`}} sin\delta + |V|^2 \frac{X_d^{`} - x_q}{X_d^{`} - x_q} sin2\delta \qquad (1)$$

Where;

E	:	no load generated EMF	(per unit)
V	:	generated terminal voltage	(volt)
δ	:	power angle	(degree)
$X_d^{`}$	:	direct axis resistance	(ohm)
x_q	:	quadrature axis resistance	(ohm)

Transient V-I Phasor Diagram is shown in Fig .1.

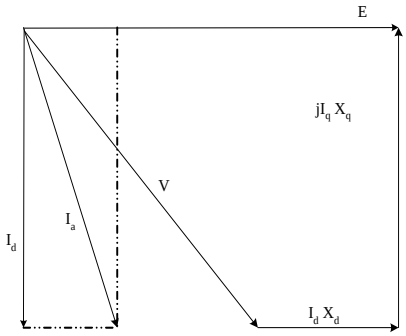

Fig. 1 Transient V-I phasor diagram

Where;

I_d	direct current	:	(Ampere)
I_a	armature current	:	(Ampere)
I_q	quadrature current	:	(Ampere)

$$\frac{Hd^2\delta}{\pi f_0 dt^2} = P_m - \frac{EV}{X_d^{`}} sin\delta - |V|^2 \frac{X_d^{`} - x_q}{X_d^{`} - x_q} sin2\delta \qquad (2)$$

In order to liberalize the equation

$\delta = \delta_0 + \Delta\delta$

$$\frac{H}{\pi f_0}\frac{d^2(\delta_0 + \Delta\delta)}{dt^2} = P_m - \frac{E_v}{X_d^{`}} sin(\delta_0 + \Delta\delta) - |V|^2 \frac{X_d^{`} - x_q}{2x_d^{`}x_q} sin\ ^2(\delta_0 + \Delta\delta)$$

(3)

$$\frac{H}{\pi f_0}\frac{d^2\delta_0}{dt^2} + \frac{H}{\pi f_0}\frac{d^2\Delta}{dt^2} = P_m - P_{max} = (sin\delta_0 cos\Delta\delta + cos\delta_0 sin\Delta\delta) - |V|^2 \frac{X_d^{`} - x_q}{2x_d^{`}x_q} sin2\delta_0 (cos2\Delta\delta + cos\delta_0\ sin2\Delta\delta)$$

(4)

$$\frac{H}{\pi f_0}\frac{d^2\delta_0}{dt^2} + \frac{H}{\pi f_0}\frac{d^2\Delta\delta}{dt^2} = P_m - P_{max}(sin\delta_0 cos\Delta\delta + cos\delta_0 sin\Delta\delta) - |V|^2 \frac{X_d^{`} - x_q}{2x_d^{`}x_q} (sin2\delta_0 cos2\Delta\delta + cos\delta_0\ sin2\Delta\delta)$$

(5)

Since,

Cos $\Delta\delta$ = 1, sin$\Delta\delta$ = δ

$$\frac{H}{\pi f_0}\frac{d^2\delta_0}{dt^2}+\frac{H}{\pi f_0}\frac{d^2\Delta}{dt^2}=$$

$$P_m-\frac{Ev}{x_d}\sin\delta_0-\frac{Ev}{x_d}\cos\delta_0\Delta\delta-|V|^2\frac{x_d-x_q}{2x_dx_q}2\sin2\delta_0-|V|^2\frac{x_d-x_q}{2x_dx_q}\cos2\delta_0\Delta2\delta \quad (6)$$

At initial operating point

$$\frac{H}{\pi f_0}\frac{d^2\Delta\delta}{dt^2}=P_m-\frac{Ev}{x_d}\sin\delta_0-|V|^2\frac{X_d-x_q}{2x_dx_q}2\sin2\delta_0 \quad (7)$$

$$\frac{H}{\pi f_0}\frac{d^2\Delta\delta}{dt^2}=-\frac{Ev}{x_d}\cos\delta_0\Delta\delta-|V|^2\frac{X_d-x_q}{2x_dx_q}\cos2\delta_0\Delta2\delta \quad (8)$$

$$\frac{H}{\pi f_0}\frac{d^2\Delta\delta}{dt^2}=(\frac{-Ev}{x_d}\cos\delta_0-\frac{|V|^2}{x_dx_q}\cos2\delta_0)\Delta\delta \quad (9)$$

Calculate *Synchronizing Power Coefficient* (P_s) ,

$$P_s=\frac{dp}{d\delta}\Big|_{\delta_0} \quad (10)$$

$$P_s=\frac{Ev}{x_d}\cos\delta_0+\frac{|V|^2}{x_dx_q}\cos2\delta_0 \quad (11)$$

When P_s is postive mean that operation at equlibriam angle will be restoredand no loss of synchroism happen . The power system and transient studies is simulated using Power Systems Analysis Framework (PSAF) program.

The output of the PSAF simulated program is fed to a newly developed artificial immunity system technique (AIS) to be analyzed in micro grid studies.

PSAF provides a new, easier way to handle studies, networks and equipment databases. It allows creating and maintaining study cases in a simple tree-like environment. The suite includes programs for load flow, short circuit, harmonic and transient stability analyses of electrical networks.

3. Immunity System

The idea of new systems is first start with the researches try to look of human brain as inspiration for development of computing system, most popular types are:

1-Artificial neural network

It has shown to be successful for a wide variety of pattern recognition and control problems [7].

2-Genatic algorithm:

It successes in solve difficult expensive optimization problem. Although this system is great but as we see it does not solve a problem with different types.

3-Artificial Immunity System:

The defense of human body one of the most amazing and mysterious phenomena, as the immunity of his body protect from any attack. It has a high accuracy so researches try to build a system similar to immunity.

Benefits of immunity system can be used in: learning, pattern recognition, anomaly detection, memory, learning and self organization and robustness and diversity.

The immunity system composed of a range of cells and molecules that work together with other systems [8].The idea based on when antigen enter body (it infect the cell, activation T lymphocytes this cause activation of B cell) it try to bind with B cell (antibody) through receptors with affinity (the strong affinity will be taken) then it form plasma cell that made colonel expansion and convert into memory cell, when the same antigen enter the body again memory cell will identify it (as shown in Fig. 2, Fig. 3, Fig. 4).

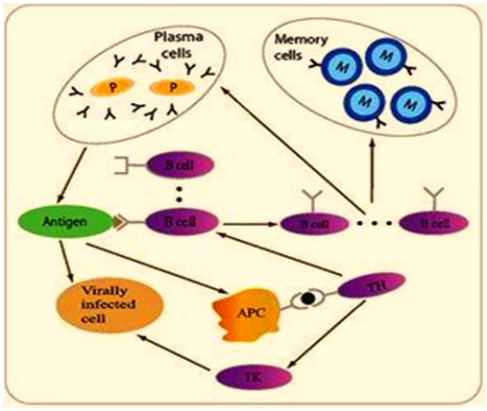

Fig. 2 Mechanism of Immune system [9]

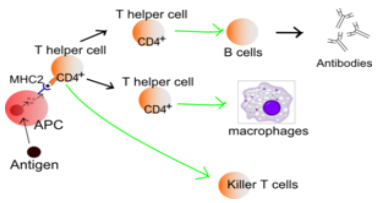

Fig. 3 Activation of T lymphocytes& B lymphocytes [10]

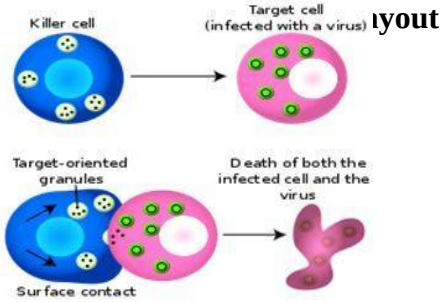

Fig. 4 PHAGOCYTOSIS [11]

Recently immunologist Irun cohen defines three types of AIS scientists [5].

1- The *literal* school that built systems in silicon to try and do what the actual immune system does (e.g. build computer security systems that discriminate between self and non-self).

2- The *metaphorical* school that look for inspiration from the immune system and build computational systems with the immune system in mind (so the application may be far from analogous to what the immune system does)

3- People who aim to understand immunity through the development of computer and mathematical models. AIS is moving into an area of true interdisciplinary and one of genuine interaction between immunology, mathematics and engineering [5].

In this paper, artificial immunity technique is developed to accomplish two tasks.

1- Artificial Immunity System Predictor (AIS)

It decides whether power system is stable or not and determines action to be taken and repot it to center protection

The algorithm based on the *metaphorical* school. Normal data represent antibody, fault case represent antigen.

Fig. 5 illustrated the *metaphorical* algorithm in form of flowchart.

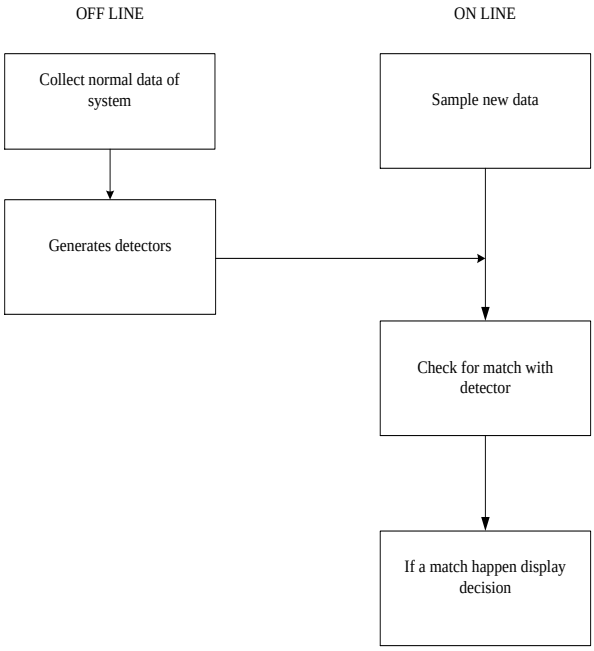

Fig. 5 Flow chart of AIS predictor (*metaphorical* school)

2-Artificial Immunity system Pattern recognition (AISPR)

It uses *literal* school algorithm, which uses that to decide which group of generators should swing together. The selected generators form an island and the step repeated to form different cases. It compared with the online case in order to provide best solution. The algorithm flowchart of the AISPR is clarified in Fig. 6.

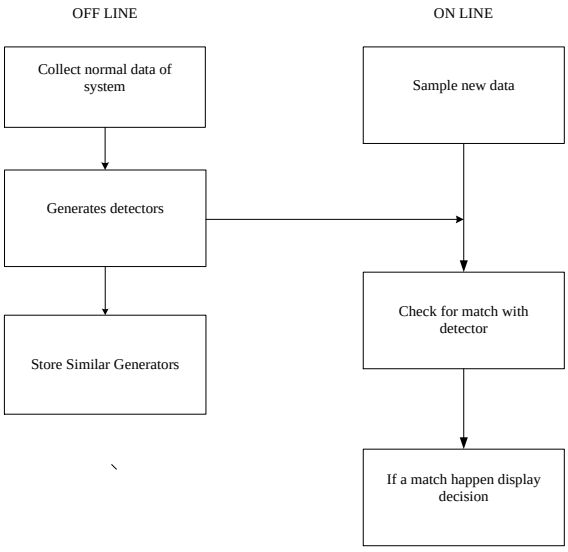

Fig. 6 Flow chart of AISPR (*literal* school)

4. Simulation And Results

The research work is realized in form of three main stages, which are summarized in the following block diagram of Fig. 7.

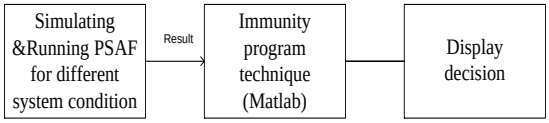

Fig. 7 Block diagram of developed work

The three stages are;

1- Simulating the IEEE 39-bus system (shown in Fig. 8) utilizing PSAF program, and running the system multiple times for different scenario.

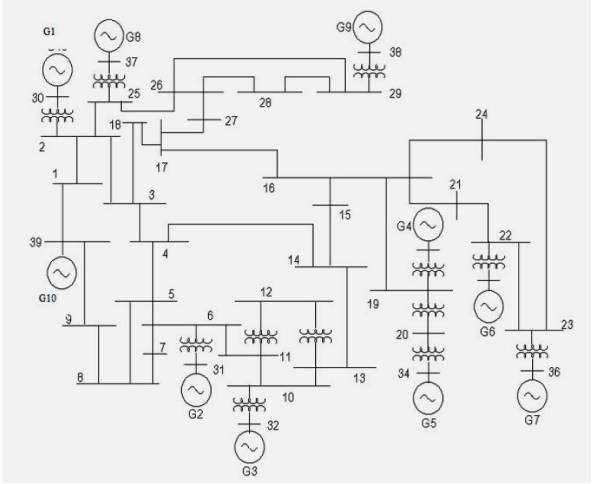

Fig. 8 IEEE 39-bus standard system

2- Anew develop AIS using the output data to accomplish the main target which are stability detection and micro grid division.
3- Display final results.

The last mentioned steps are shown in details in the flow chart of Fig. 9.

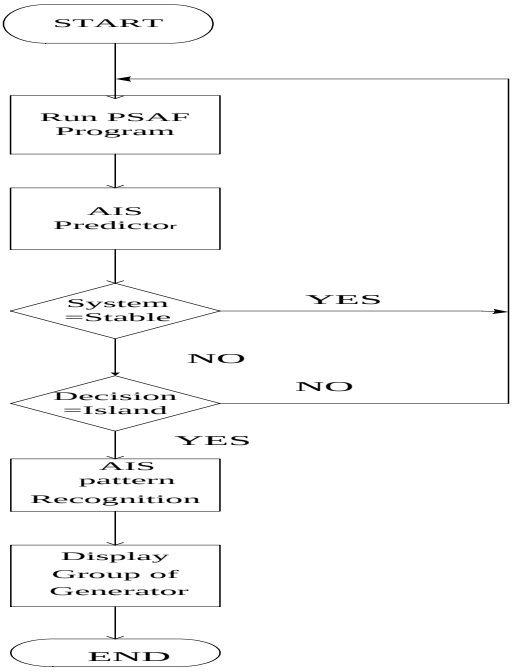

Fig. 9 flow chart of the system

After running the previous algorithm for different power system condition exactly 67 different cases. The new developed technique showed high flexibility and give efficient results. Some of these cases are discussed in details.

The proposed AIS is tested by applying cascaded faults on buses 18 and 2 respectively, the first fault cleared by disconnecting line 2-25 after 11 cycle, while the second fault cleared by disconnect line 17-18 after 16 cycle, as seen in PASF output Fig. 10 the system loose synchronisms and instability condition occurred. The drop on voltage to 0.2 per unit may cause damage to the generator.

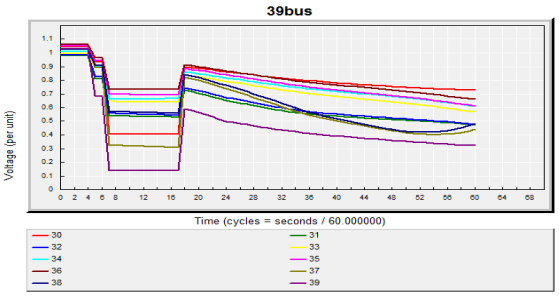

Fig. 10 Generators Bus Voltage for applying cascaded fault 21

The developed technique is used to apply the concept of micro grid. The shown results are decided utilizing the developed technique, where the system is divided into 3 islands as the following:
Group #1: G1, G10
Group #2: G2, G3
Group #3: G4, G5, G6, G7 and G8

After applying the technique major change happen to the system. The voltages of the system generators (except G5) operate within the range 1.03 to 0.98, which is the accepted tolerance of the IEEE standard (± 10 % of nominal voltage), as illustrated in matlab Fig. 11. G5 is tripped to improve the performance of the system, as seen in Fig. 12. This technique guarantees the continuity of service and reliability of the system. More rapid and accurate results are available, which didn't occur when p_s coefficient t is calculated.

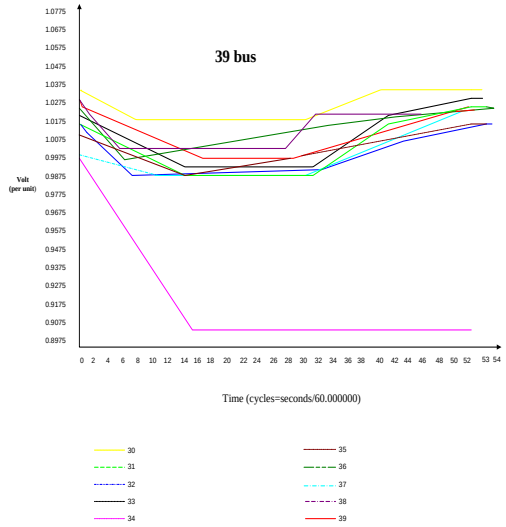

Fig. 11 Generators Bus Voltage after Applying AIS Development techniquemicro grid

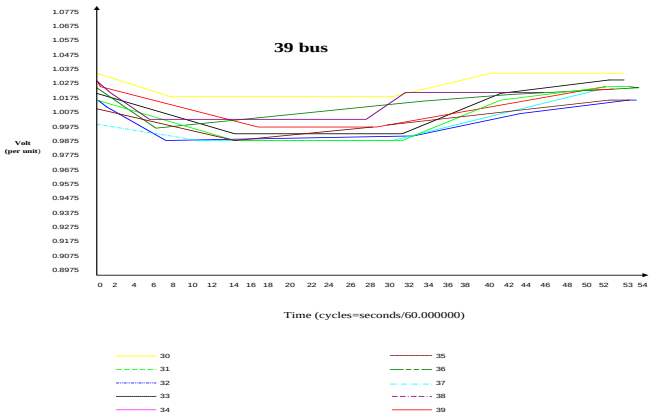

Fig. 12 Generators Bus Voltage after tripping G5

4. Conclusion

Transient faults detection and protection are vital tasks in electrical power system. Reliability of power systems also considered a main issue in efficient systems, which leads to the idea of this work. A newly approach, using AIS technique, are developed to detect the response of generators during transient behavior of the system, in this paper. The concept of designing micro grid is applied for protecting system and guarantee power system reliability. The work is progressed through three main parts. First part is simulating power system using PSAF. Second part is the developing of AIS technique to detect system stability and using AISPR to divide network to micro grids containing group of generator in order to solve instability problem and insure continuity of service. Third part is displaying final result. The newly AIS approach defense against transient instabilities is demonstrated on the IEEE 39 bus system shows very good result in expecting system behavior and in treating instability problem. Prediction window of 6 cycles succeed in predict stability mode. Micro grid designing technique helps the system to recover back after the occurrence of the disturbance. Ability of this system can be improved by adding more results and store it as antibody.

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