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AUTOMATIC GENERATION CONTROL SYSTEM FOR FREQUENCY STABILITY ON TWO AREA NETWORK

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ABSTRACT

Load fluctuations are inevitable as power consumption continues to rise. Frequency instability results from this imbalance between power generation and consumption. This study uses autonomous generation control to ensure frequency stability in the IEEE 10 Bus power system by controlling the generation of electricity to keep the system's frequency constant while also adapting to fluctuations in load. Frequency stability in a two-area, four-machine, interconnected IEEE 10 bus power system is achieved with the help of an emulated Automatic Generation Control (AGC) system, which can be found in the EUROSTAG version 4.5 software.

Keywords – Automatic Generation Control,Two area of IEEE 10 Bus System, Frequency Stability, EUROSTAG.

1. INTRODUCTION

The reliability and safety of the power system are ensured by its ability to maintain a balance between power generation and load demands. This balance is maintained so that the frequency of the network remains within the parameters set by the grid codes. The demand for power, or the load, is very variable during real-time operations, and the resulting load-generation balance is often only partial. The system's frequency, and hence its reliability, is perpetually influenced by this relative equilibrium. The frequency of the electricity system is principally regulated by means of two control loops, the primary and secondary. The primary control loop prevents sudden frequency shifts before the frequency protection switches are engaged. The steady-state error is often caused by the governor's drooping provisions for this. Secondary control, also called automatic generation control (AGC) or load frequency control (LFC), is a method used in the power system network to maintain a constant nominal frequency. The AGC functions to (a) keep the power flowing through the tie-lines close to the predicted value, (b) keep the steady-state system frequency at its nominal value, and (c) limit the amount of time it takes for the frequency to overshoot and settle. The linear equation known as area control error (ACE) uses the two primary target variables, frequency variance and tie-line power exchange, to accomplish this. ACE is used as a monitoring signal by AGC, which resets it to zero if there is a change in load. The proposed distributed MPC architecture is so efficient that it can match the performance of centralised MPC [1]. Analysis of the long-term impact of randomised demand response on the mean and variation of system frequency [2]. A power system optimization perspective on autonomous generation control and economic dispatch [3]. Whether virtual inertia or droop frequency regulation is more suited for this form of collaboration [4] is determined by a small-signal study. Both centralised and distributed control systems are investigated as possible means of coordinating [5] to ensure that the PHEV and wind generator restrictions are not exceeded. Using Governor Dynamics Differential Algebraic Equations to Maintain Frequency Stability [6]. Fractional order control and a data-driven control underpin the stability study of microgrids employing adaptive frequency control [7]. Using the PSAT toolbox, we developed a clever automated generation control (AGC) for Smart Grids. Analysis of Power World and PSAT, two load flow simulation software packages. ETAP software analysis of transient network stability [9]. Multi-Machine Study of Transient Stability [10] is performed with Power World Simulator. The reliability [11] can largely be attributed to the application of AI and optimization methods.

2.BLOCK DIAGRAM OF THE TWO AREA SYSTEM

From the foregoing literature analysis that an examination of frequency behaviour under varying loads is required. Variations in load cause inconsistencies in frequency. No matter how much or little power is transferred through the tie lines, the flat frequency management mechanism always brings everything back to their original frequency. In order to keep the system frequency stable under varying loads, the research proposes an automatic generation control system.. The objectives of the work areto analyse and control the frequency behaviour under different loading conditions and to maintain the system frequency.

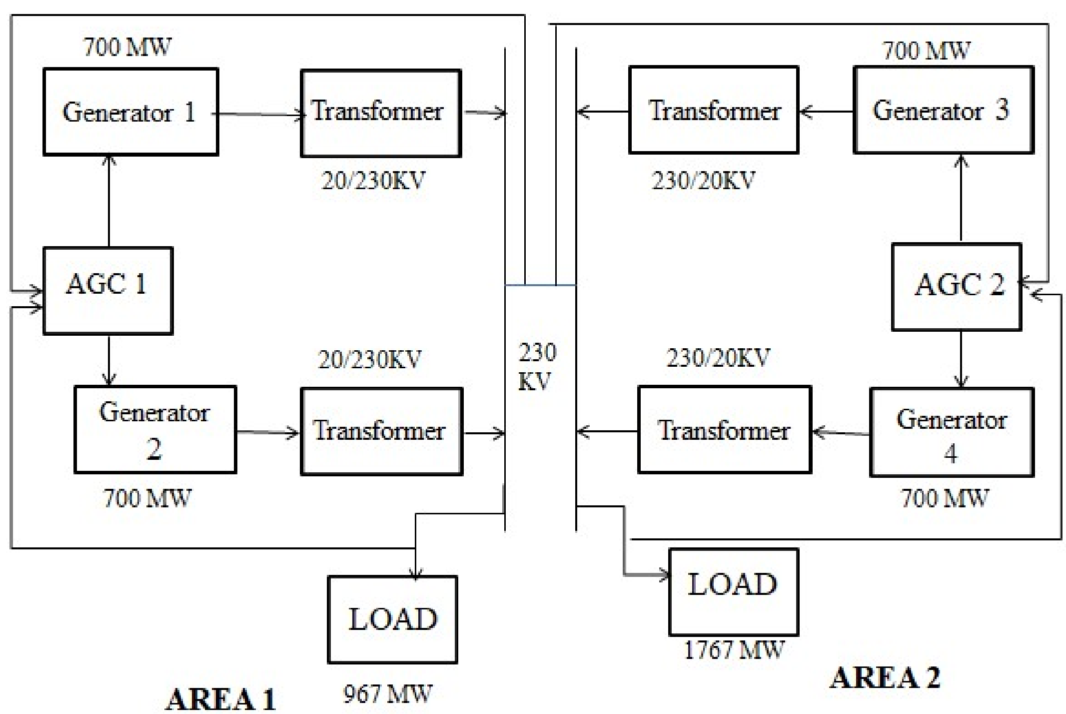

Fig.1 Block Diagram of Two Area system of IEEE 10 Bus System

Over in Fig.1, we see a block diagram illustration of the IEEE 10 Bus system's two-area, four-machine architecture. In Zone 1, you'll find AGC1 and the two generators, G1 and G2. In response to changes in load, AGC1 modifies the output of generators G1 and G2. In Zone 2, you'll find AGC2 and the coupled generators G3 and G4. The AGC2 regulates the output of generators G3 and G4 in response to changes in the load. Both AGCs receive as input the power and frequency of the generators' tie lines as determined by the load changes. In a two-area system, the power output of generators is adjusted by the output of both AGCs, and system-wide frequency stability is maintained.

3.METHODOLOGY

WHALE OPTIMIZATION ALGORITHM

Whale optimization algorithm (WOA) The WOA approach is a naturalistic, meta-heuristic search strategy. It's no secret that whales, which can reach lengths of 30 metres and weights of 180 tonnes, are the largest living mammals on Earth. There are many different kinds of it, and these are them.,(i)Killer(ii)Sei(iii)Humpback (iv)Right (v)Finback (vi)Blue

As only half of their brains are asleep at any given moment, they are mostly predators. That's because they have to come up to the water's surface to breathe. They are highly perceptive and intellectual beings. Spindle cells, which are crucial for human emotion, social behaviour, and judging qualities, are present in whales as well. Our unique set of cells is what sets us apart from our fellow members of the species. In contrast, whales have around twice as many, making them exceptionally intelligent. In this respect, whales are similar to humans in that they are capable of thought, learning, communication, and even emotion. They can obviously develop their own language. Whales have the option of living alone, although most do so in pods. A killer whale's offspring is extremely family-oriented, choosing to remain with their parents and siblings for the whole of their lives. A member of the whale family, the humpback whale is approximately the size of a school bus. The species is known by its scientific name, Megaptera novaeangliae. Common prey includes krill and schools of small fish. One of the most notable features of humpback whale hunting is the employment of a bubble net to catch prey. Because of their social nature, they often pursue their prey quite near the water's surface. They can make bubbles that look like the number nine or in the shape of a circle. This is their method of food acquisition. It wasn't until 2011 that submersibles were used to do the deep-sea exploration and observation that had been.

Mathematical Modelling WOA model can be explained in three stages namely,

1. Encircling prey
2. Spiral bubble net feeding maneuver
3. Search for prey

These are one by one explained below.

1. **Encircling prey :-**Even though the prey's location is originally unknown, it may end up learning it and then being surrounded. Because of what was just said, the current location—which is also the best response for now—is selected as the primary quarry (optimal position at first is not known). Once the best search agent position has been identified, the positions of the other search agents will be updated accordingly.

2.Bubble-net attacking method:-Exploitation is taking place at this point. It contains two approaches, which are explored in the parts that follows.

a) Shrinkage Enclosing Mechanism. It is accomplished via reducing. A additionally narrows the A's range of fluctuation. The range [-a, a] contains all possible values for a. A search agent may at any time hold a position between the current best agent position and the agent's original position if the interval in which it falls is [-1, 1]. The location that is conceivable from (X, Y) towards (X*, Y*) is shown in the image below. Via the use of 0A1 in 2D space, it is possible.

b) Position for Spiral Update Distance between a whale at (X, Y) and its prey at (X*, Y*) calculated. In order to create the spiral equation between their various locations, humpback whales' helical movement is imitated.Thus, |X(t)|= distance of ith whale from whale (best solution so far). The logarithmic spiral shape is defined by the constant b. random number in the range [-1, 1].

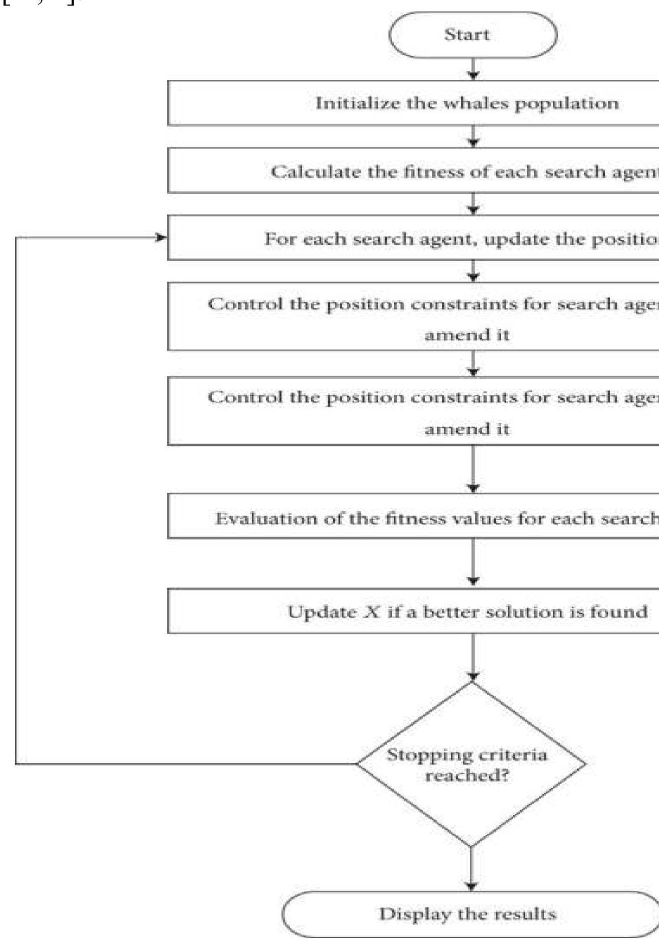

Fig.2Flowchart for the Whale Optimisation Algorithm.

3. Search for Prey :-The phrase "exploratory period" accurately describes this time. It depicts a scenario where humpback whales randomly forage for food in relation to one another. In this case, too, the search is organised around the A variant. It was applied to an arbitrary number, typically one that was either larger than or less than one. "That's why brokers have to abandon the reference whale. Rather than always employing the most effective search agent, a random one is now used to update positions. The combination of this and |A|>1 allows for a worldwide search to be conducted.Fig.2 describes the process of Whale Optimisation Algorithm in flowchart.

4. EXPERIMENTAL SIMULATION RESULTS

Using the EUROSTAG 4.5 program's network editor, we model an IEEE 10 Bus power system with a two-area system consisting of four generator buses and two load buses. There are two components of the system, and they are connected via a single tie line. Each zone has two generating units, each with a 900 MVA and 20 kV capacity. The technical specs of the system are as follows: The generators G1, G2, G3, and G4 are linked to the respective buses 1, 2, 3, and 4. As for the groups, G3 and G4 are active in Area 2, while G1 and G2 are active in Area 1. Step-up transformers are used at each generator terminal to increase the voltage from 20 kV to the required 230 kV for transmission. The combined loads on Bus 7 are 972.15 MVA with a lagging power factor of 0.9946, while the combined loads on Bus 9 are 1769.82 MVA with a lagging power factor of 0.9984. Capacitor banks supply load buses 7 and 9 with reactive power of 200MVAr and 350MVAr, respectively. System modelling predicts a 400 MW power transfer from region 1 to region 2.

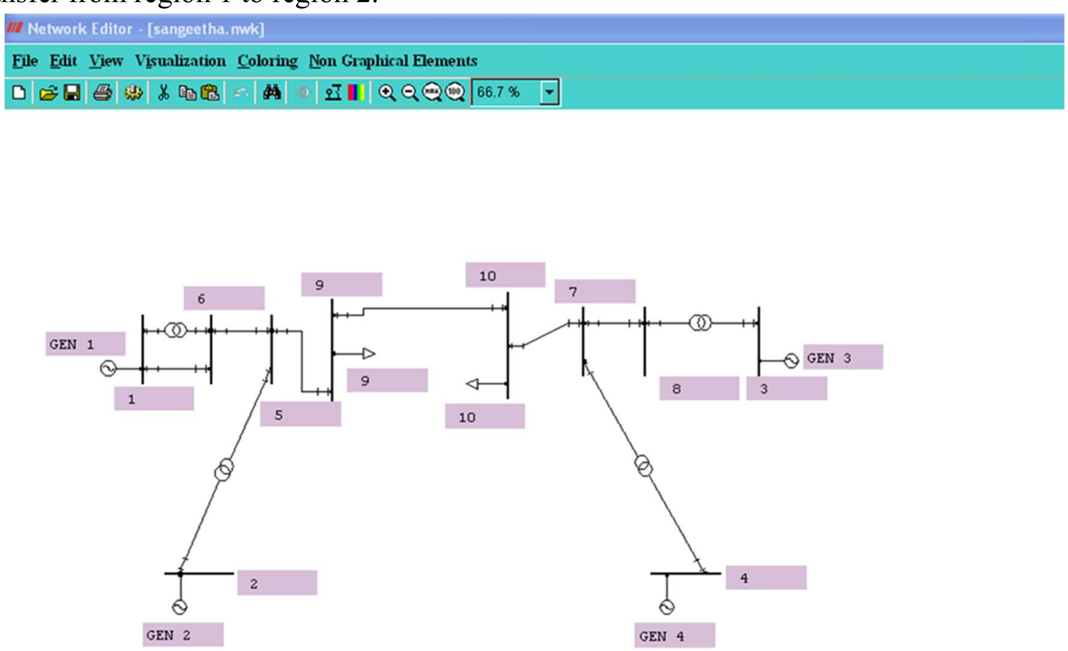

Fig.3Simulation diagram of Two area four machine system of IEEE 10 Bus system

Fig.3 shows the simulation diagram of two area four machine system of IEEE 10 bus power system simulated in network editor of EUROSTAG 4.5 software.Table 1 provides information on generator loading based on 900 MVA and 20 kV basis, and all the generators are identical.

Table 1 Generator loading data ofthe two-area system

Generator	Real Power P (MW)	Reactive Power Q (MVAr)	Bus voltage magnitude (p.u.)	Bus voltage phase angle (°)	Inertia H (s)
G1	700	184	1.0	21.2	6.5
G2	700	234	1.02	11.5	6.5
G3	700	175	1.04	-5.8	6.175
G4	700	201	1.0	-16.0	6.175

The step-up transformers linked to the generators are modelled after an ideal wye-yoke three-phase transformer with a turns-ratio of 0.086956:1 and an off-nominal ratio of 1. On the low voltage side, where their per-unit value is established, transformer reactances are modelled. At a 900 MVA load and a 20/230 kV supply, the transformer impedance is 0 +j0.15 per phase. Table 2 details information about the transmission lines used by the two-area system.

Table 2 Transmission line data for the two-area system

Transmission line	R (Ω)	XL (Ω)	BC (μMho)
1-6	1.4225	12.225	0.23232
6-5	0.629	6.29	0.43081
3-8	5.719	57.19	0.13007
5-9	5.719	57.19	0.13007
7-10	0.629	6.29	0.43081
9-10	1.4225	12.225	0.23232

Loads are connected at buses 7 and 9.The actual loads and load impedances at each load bus are listed in Table 3.

Table 3Load data for the two-area system

Bus	Real Power PL (MW)	Real Power RL (Ω)	Reactive Power QL (MVAr)	Reactive Power XL (Ω)
9	967	51.15	100	494.66
10	1767	29.28	100	517.42

Case 1: Load increases by 10% at Bus 9 at Area 1

Bus 9 has a 967 MW load connected to it, and upon first loading the frequency stability drops from 50 Hz to 49.5 Hz. As the load rises by 10% at Bus 9, the Automated Generation Control System will begin to raise output. Bus 9 is carrying a load of as much as 1067 MW. The 700MW generators (G1 and G2) are managed by Automated Generation Control (AGC1). In order to accommodate the 10% load increases at Bus 7, AGC1 of Area 1 makes adjustments to the 550 MW in generating output power from G1 and G2. In order to get the system frequency of 50 Hz in under 10 seconds, Automated Generation Control (AGC1) regulates the frequency. In Fig.4, we can see the Area 1 frequency stability that was achieved by AGC1..

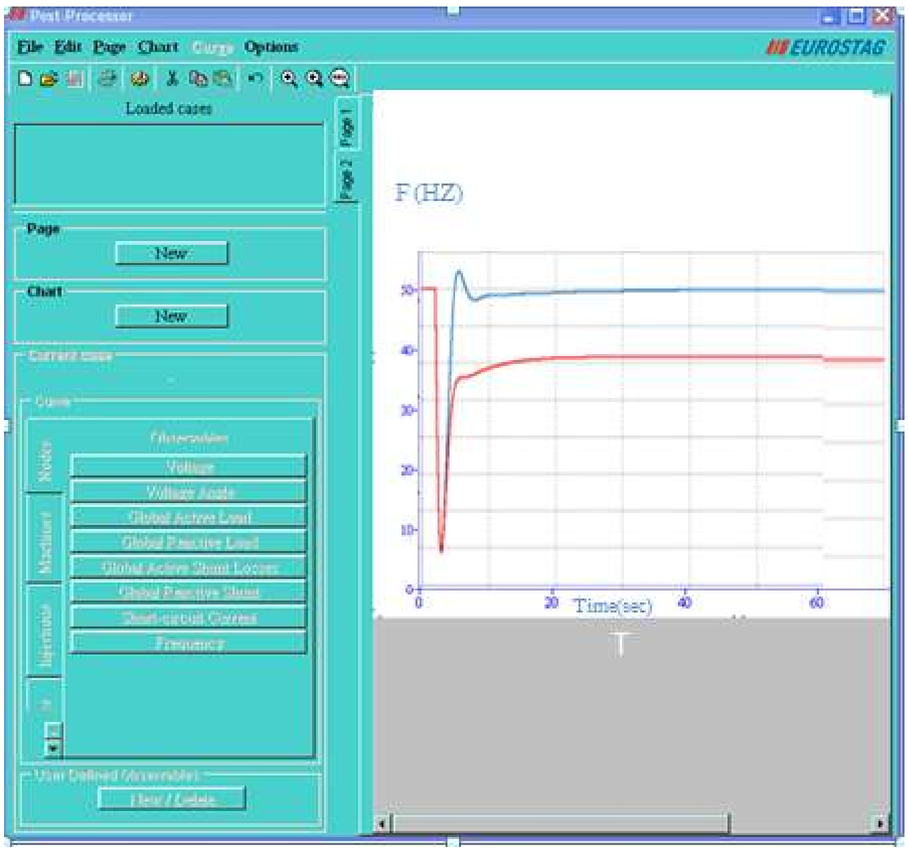

Fig.4TheFrequency stability attained by AGC1 in Area 1.

Case 2: Load increases by 10% at Bus 10 at Area 2

Frequency stability drops from 50 Hz to 48.4 Hz when bus 10 is loaded with a 1767 MW, 100 MVAr load. As the demand at bus 10 rises by 10%, the ACS steps in to increase generation. At Bus 10, the load peaks at 1935 Megawatt. The 700MW G3 and G4 generators are managed by Automated Generation Control (AGC2). To accommodate the 10% load increases at Bus 10, AGC2 of Area 2 modifies the 550 MW output power of generators G3 and G4. In order to get the system frequency of 50 Hz in under 10 seconds, Automated Generation Control (AGC1) regulates the frequency. Figure 4 depicts the Area 2 frequency stability achieved by AGC2.

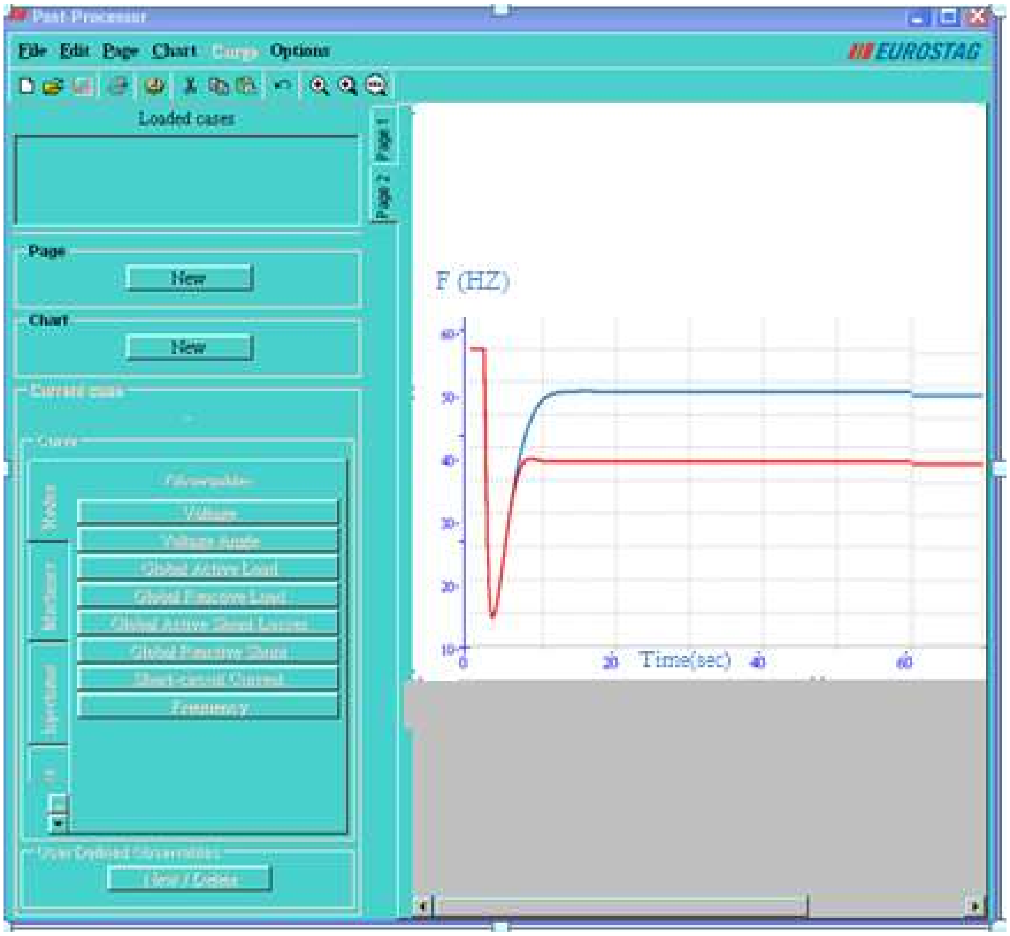

Fig.5 The Frequency stability attained by AGC2 in Area 2

5. RESULTS AND DISCUSSIONS

AREA1 WITH AGC 1		AREA2 WITH AGC2		UNDER FREQUENCY LOAD SHEDDING
LOAD	**LOAD INCREASES BY 10% WITH AGC1**	**LOAD**	**LOAD INCREASES BY 10% WITH AGC2**	**LOAD**
Load **967 MW**	**Load** **1067MW**	**Load** **1767 MW**	**Load** **1935MW**	**Load** **967 MW**
Frequency **49.8 Hz**	**Frequency50 Hz**	**Frequency** **49.3 Hz**	**Frequency** **50 Hz**	**Frequency** **48.6 Hz**

Time **10 secs**	**Time** **10 secs**	**Time** **10 secs**	**Time** **10 secs**	**Time** **80 secs**

Table 4 Comparison between AGC and UFLS for the two area system

In Table 4, we can see how Under Frequency Load Shedding compares to Automatic Gain Control in a two-area IEEE 10 Bus system. Frequency stability in a two-area system can be achieved by Under Frequency Load Shedding in a matter of 80 seconds by operating at a frequency of 48.6 Hz. When the load in Area 1 fluctuates from 967 MW to 1067 MW, the frequency of the entire IEEE 10 Bus system remains stable thanks to Automated Generation Control. System frequency is stable when the load in Area 2 changes from 1767 MW to 1935 MW, as measured by AGC 2". When compared to Under Frequency Load Shedding in an IEEE 10 Bus system, the time it takes for Automatic Generation Control (AGC) 1 and AGC 2 to achieve frequency stability is significantly shorter.

CONCLUSION AND FUTURE EXTENSION

So, the purpose of this study is to examine the frequency behaviour in a range of loading conditions. The IEEE 10 Bus system's two-area, four-machine frequency stability is quickly achieved with the help of Automatic Generation Control and the EUROSTAG software. This short presentation of the EUROSTAG programme contained AGC models built with the Macro-Block component. The impact of this effort can be magnified by using renewable energy sources like solar and wind. Changes in frequency are typical when the wind speed varies continually. For this reason, if there is an unexpected decline in generation, the system's frequency will fall. The necessity of AGC control to maintain the frequency at the standard 50 Hz can thus be proved.

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