Virtual Model for Automatic Synchronization of Alternator with Infinite Busbar using MATLAB SIMULINK

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ABSTRACT

Now a days, Load demand is increasing due to increasing use of electric power. Existing system may not be sufficient to meet with the demand and hence additional units of alternators to be added to satisfy the increased demand. Synchronizing a generator to the power system must be done carefully in order to prevent damage to the generator and disturbances to the power system. Traditionally, manual adjustments are done by the skilled operator for synchronization of alternator. Here we are using MATLAB SIMULINK to create the virtual model for the designing and real time operation for automatic synchronization of alternator with infinite bus bar. Along with the auto synchronization the parameters like voltage, frequency, phase angle and phase sequence are monitored by using MATLAB SIMULINK. The developed automatic synchronization unit is reliable and precise to be used for monitoring, measuring and parallel operations of the synchronous generators.
Keywords—Synchronization, Auto synchronizer, Alternator, Busbar, Microcontroller.

I. INTRODUCTION

The process of connecting and operating two or more alternator in parallel to each other or connecting one alternator to the infinite bus bar is known as synchronization of alternator. Electrical power generation and transmission system consists of the interconnection of large numbers of alternator operating in parallel, interconnected by transmission lines and supplying a large number of widely distributed loads. The phase sequence, voltage and frequency of the infinite bus bar are mostly same and considered constant. There are many benefits of parallel operation of alternator like the continuity of power supply, reliability, expandability, flexibility and high efficiency. The above mention needs cannot be met by a single alternator so several alternators are connected in parallel to supply power for large loads. During periods of scheduled maintenance, inspection, damage, light load, one or more alternator may be shut down and cut off from the infinite bus bar. During when the remaining alternator operate to meet the power demand of loads and maintains the continuity of supply. If there is an increasing demand in future machines can be added without disturbing the original installation. The manual method of synchronization demands a skilled operator and is suitable for no-load operation or normal frequency condition. Under emergency condition such as lowering of frequency or synchronizing of large machines a very fast action is needed, which may not be possible for a human operator. Synchronizing a generator must be done carefully.

Poor synchronizing can:

1. Damage the generator and prime mover.
2. Damage the generator and step up transformer windings caused by high currents.
3. Cause disturbances such as power oscillations and voltage deviation.
4. Protective relay element interprets the condition as an abnormal operating condition and trip the generator.

Hence there is a need for automatic synchronization. In automatic synchronization process, the adjustment of the magnitude of phase voltage, phase angle, phase sequence and the generating frequency of the incoming alternator is done automatically. When all the parameters of synchronization are satisfied and

synchronized with that of the infinite bus bar, the incoming machine is connected to the infinite bus which is done by the electrical contactors under the instructions from microcontroller. The automatic synchronization of alternator uses microcontroller which makes the synchronization technique much user friendly.

II. OBJECTIVES

The main objective of this paper is automatic synchronization of alternator to provide uninterrupted power supply as per load demand. The adjustment of magnitude of voltage, frequency, phase angle and phase sequence of incoming alternator is done automatically. Under emergency condition such as lowering of frequency or synchronizing of large machines a very fast action is needed, which can be provided by automatic synchronization process. A MATLAB SIMULINK is an interactive, graphical environment for modeling, simulating, and analysing of dynamic systems which overcome the problem of existing tools. The operation of auto synchronization of alternator is illustrated by using MATLAB SIMULINK. The aim of our paper is to create the virtual model for the designing and real time operation for automatic synchronization of alternator with infinite bus bar.

III. METHODOLOGY

A. Introduction to Matlab Simulink

Simulink, an add-on product to MATLAB, provides an interactive, graphical environment for modeling, simulating, and analyzing of dynamic systems. It enables rapid construction of virtual prototypes to explore design concepts at any level of detail with minimal effort. For modeling, Simulink provides a graphical user interface (GUI) for building models as block diagrams. It includes a comprehensive library of pre-defined blocks to be used to construct graphical models of systems using drag-and-drop mouse operations. The user is able to produce an "up-and-running" model that would otherwise require hours to build in the laboratory environment.

B. Model Creation

Creating a working model with Simulink is straightforward. The process involves four basic steps as depicted in the following flowchart.

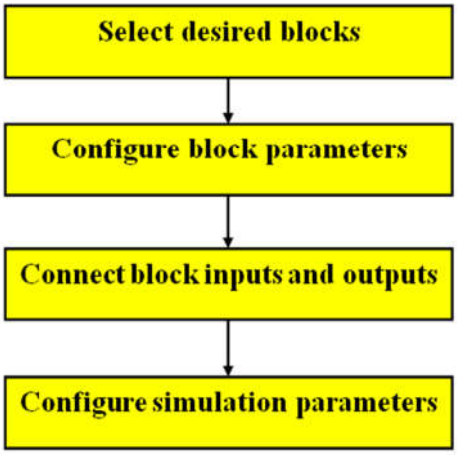

Fig.1 Flowchart for Model Creation

First you will gather all the necessary blocks from the Library Browser. Then you will modify the blocks so that they correspond to the blocks of the desired model. Lastly, but not the least, you will connect the blocks with lines to form the complete system and set the overall simulation parameters. After this, you will simulate the complete system to verify that it works.

C. Simulink Model Design For Auto Synchronization

As it is an auto synchronization, the whole process will run automatically with the help of controller. There are four major parameters have to be matched for synchronization of alternator with bus bar. They are

- Voltage
- Frequency
- Phase angle
- Phase sequence

1) Block Diagram and Flowchart*:* The above block diagram shows simplified connection of automatic synchronization. Here generator-1 is the reference generator which is already connected to a busbar and the load is also connected to the busbar.

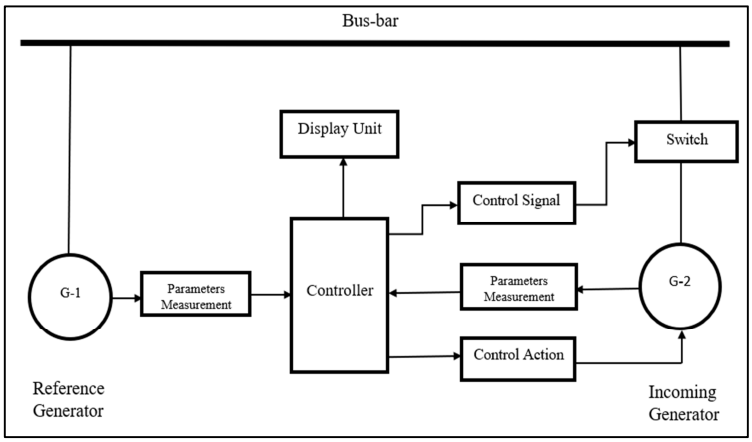

Fig. 2 Block diagram of auto synchronization

In order to connect a new incoming generator (G2) to the bus bar some of the parameters need to be satisfied such as voltage, frequency, phase angle and phase sequence same as that of the reference generator.

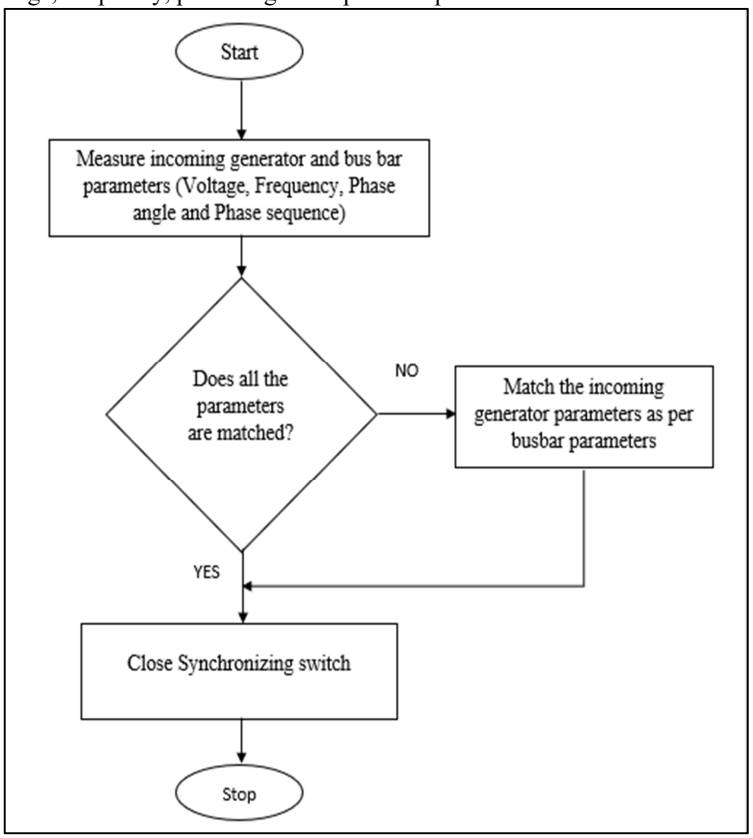

Fig. 3 Flowchart for auto synchronization

The parameters of reference generator are fetched and given to controller. Now the parameters of incoming generator are compared with reference generator G1 and controller will adjust the parameters of incoming generator same as that of the reference generator. When all the parameters are satisfied then the controller sends control signal to the switch, which will change the status of switch and new incoming generator is get synchronized with busbar.

2) Design of Simulink Model*:* The virtual Simulink model for the designing and real time operation for automatic synchronization of alternator with infinite bus bar is shown below.

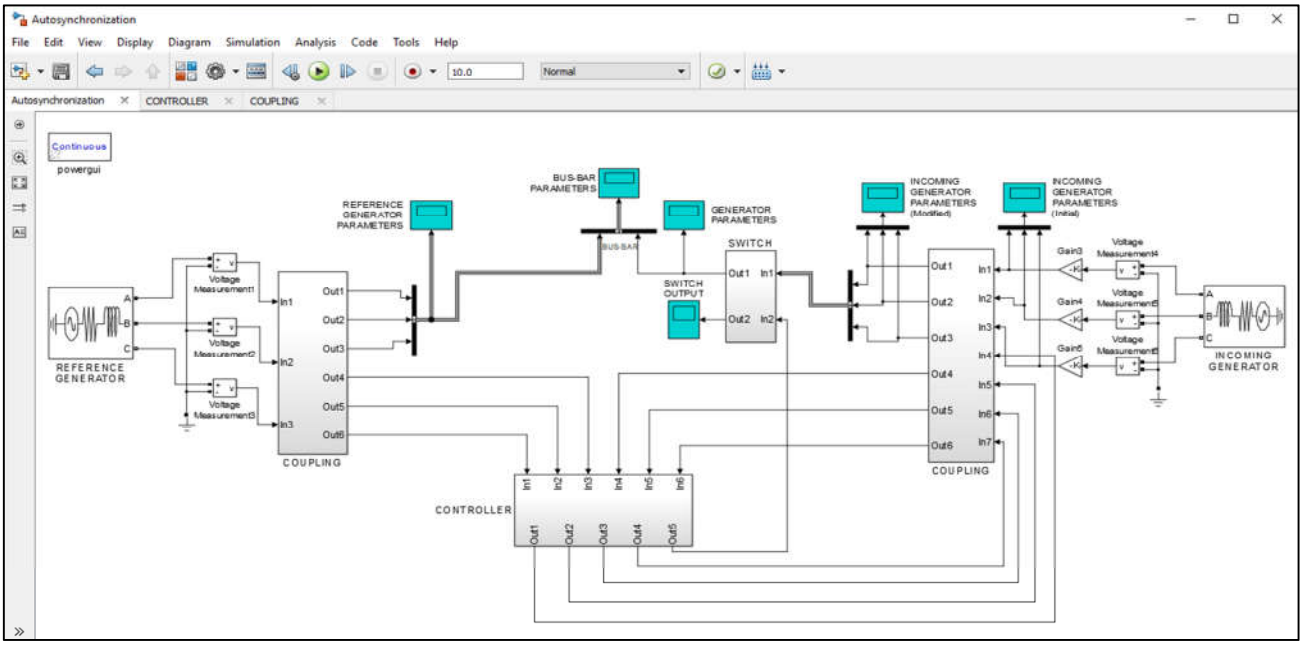

Fig.4 Simulink Model for Auto-synchronization

The proposed system is simulated according to single line diagram of Fig.2 and consists of a three-phase reference alternator connected to bus bar and another three-phase incoming alternator that should be synchronized and tied with a three-phase infinite busbar. In between, there is a switch that will operate based on controller signal. Other peripherals have been used such as a controller to synchronize alternator to grid as shown in Fig.4 along with that coupling-1 and coupling-2 subsystem blocks are used to reduce the complexity of model.

Controller subsystem block consist of all control actions which includes comparison between the parameters of reference generator and incoming generator. If the parameters are matched then, controller sends the signal to a switch to close, otherwise controller sends the control signal to the incoming generator to adjust its parameters same as that of reference generator.

IV. SIMULATION RESULT

Inputs: Reference generator Incoming generator
Line voltage - 440V Line voltage - 500V
Phase angle – 0 Phase angle - 240
Frequency – 50 Frequency – 100

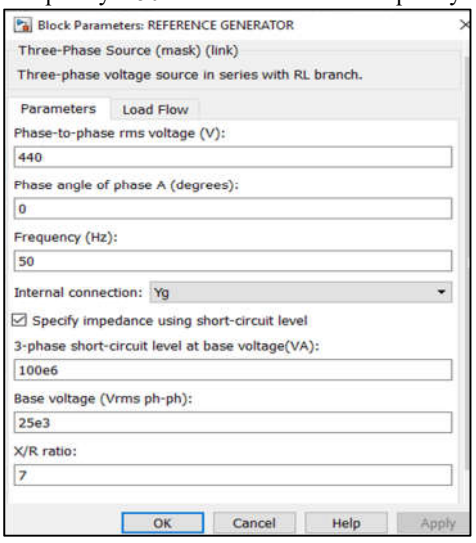

Fig.8 Incoming generator parameters

Output: Incoming generator parameters after control action taken by controller.

Line voltage – 440V

Phase Angle – 0º

Frequency – 50Hz

Phase Sequence – RYB

Waveform showing position of Switch (0 for open and 1 for close) Position of Switch – 1 (Closed) as shown in fig 11

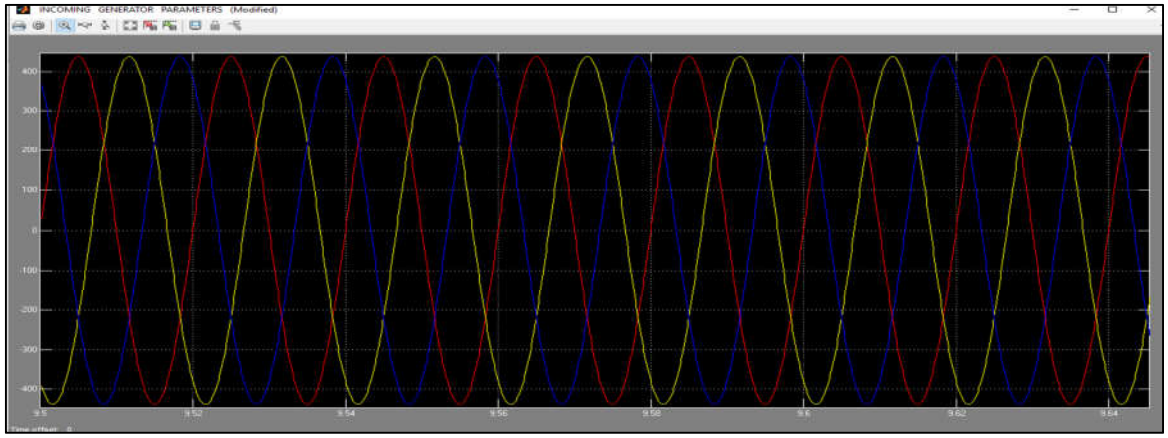

Fig.9 Output waveform of incoming generator

Fig.11 Output waveform of switch

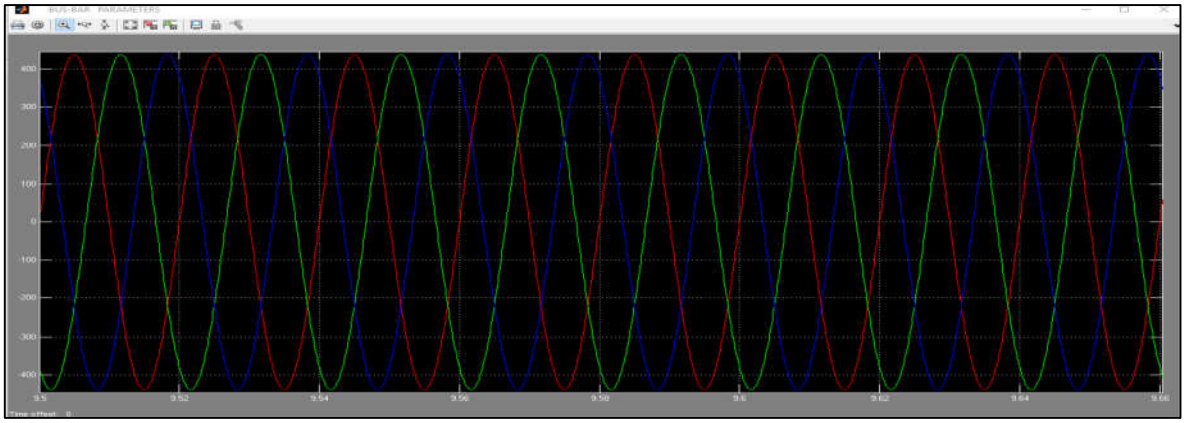

Fig.12 Output waveform of bus bar

V. ADVANTAGES

1 Reliability of the whole power system increases.
2 Simulink model gives visualize results without the need for complicated and time-consuming programming.
3 Simulink model provides behavior of the system without building it.
4 Precise to be used for monitoring, measuring and parallel operations of the synchronous generators.
5 Because of proper synchronization there are no disturbances such as power oscillations and voltage deviation.
6 More convenient than conventional method.

VI. DISADVANTAGES

1 Auto synchronization Simulink model may be very expensive in practical implementation.

VII. APPLICATIONS

1. Power grid and Industrial applications

VIII. CONCLUSION

In this paper, a simple yet effective technique for digital synchronization of an alternator to the grid has been presented. Moreover, the technique enabled automatic control over the power delivered to the grid through the alternator by satisfying Synchronization parameters. The presented results illustrate the system operation over wide range of references ensuring the stability of the system. These results reveals the novelty and effectiveness of the proposed system. The parameters like voltage, frequency, phase sequence and phase angle of alternator and busbar are observed using scope.

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