

Soft Synchronization of a Microgrid

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ABSTRACT

In today's energy scenario microgrid concept has emerged as an extremely important as it is expected to provide multiple advantages such as financial and environmental along with power reliability and superiority of power system. Inverter based distributed generation is yet to prove a lot but alternator-based CHP and diesel plants have been established and are high in terms of reliability and efficiency. However it is necessary to match the synchronization criteria (i.e. difference of voltage phase-angle and frequency of the grid system and alternator output) and control the breaker. In such cases traditional synchronization may generate high short circuit current, vibrations and may ultimately lead to trip condition if there is any operator malfunction. In this paper, an alternative to traditional synchronization is proposed. A case study of a local sugar industry is taken up and effectiveness and applicability of the proposed algorithm is proved with results. A test system is simulated and studied using MATLAB/Simulink and SimPowerSystems. Traditional methods of synchronization are studied and compared and advantages of the proposed strategy are highlighted using results from MATLAB.

Keywords: Softsynchronization, Microgrid, CHP, Co-Generation.

I. INTRODUCTION

In last few years the number of individual distributed generators or co-generation plants connected to the main grid has increased substantially. These are the subsystems of distributed energy sources along with their respective load and are popularly termed as microgrid. There are many factors that are involved for this but major ones are increasing load demand, need for increased reliability of power and economically viable governances for distributed generators. This has created a competitive environment in the energy market. Microgrids are expected to bring small renewable generating plants to mainstream power plants by working in synchronism with the grid. This will improve not only the economic aspect of the systems but environmental aspect as well by bringing the CO₂ emission rates down to a much acceptable level.

There are many major advantages of such microgrid systems. They can be connected to main grid as and when needed but can also lie standalone when required. They have variety of voltage levels to offer and can be

connected to any part of the transmission line i. e. high voltage levels, medium or low voltage levels. Preferably for most applications it is assumed or assured that they find a place near to load centers or near to major loads. This thereby improves its efficiency by avoiding the route of transmission line and also its reliability as it is nearest to the load.

Earlier these microgrids were mostly standby backup systems sharing only a limited amount of load. Now the trend is to work in parallel with the main grid and supply power to its full efficiency as and when available. The frequency of these alternators to be connected with grid has increased from few days to few hours. As the event of connecting these microgrids or co-generation plants have increased, manual triggering of grid circuit breaker is out of question. It has many disadvantages

There major technical challenges that need to be handled along with the economic aspects of the microgrid systems as the risks concerned with the increased interconnections also goes on increasing. Main issue is protection of such systems and main grid is susceptible

to heavy loads at high voltage levels and even a decent amount of transient may cause extreme damage to microgrid connected to it. Voltage, frequency, phase sequence, phase angle and power quality are main parameters that must be considered when designing a microgrid. These parameters need to be controlled to acceptable standards.

Our aspect in this project solely lies with the synchronization of one such steam turbine alternator based system forming a microgrid wherein the traditional manual synchronization techniques can be replaced with new-age automatic synchronization method thus ensuring reliability, least transients on both main and microgrid which guarantees durability of the connected equipment and to minimize the chances of synchronization failure by controlling the distributed generator automatically by generating an offset commend based of differences between main grid parameters and microgrid.

II. METHODS AND MATERIAL

1. Traditional Synchronizing Methods

Synchronization: Process of connecting one alternator in parallel with another alternator or with an infinite busbar system is known as synchronizing [1-2]. When paralleling ac generator with other generator, it essential to make the values of frequency, difference of phase angle, and difference of voltage as little as feasible. For proper synchronization these three conditions considered as criteria of the synchronizing. After satisfying above criteria we can operate CB and two different ac systems may get connected in parallel. Basic synchronizing criteria for synchronization of two generators is, voltage, frequency, phase angle and phase sequence of both generators must be equal. Criteria for Synchronization of a microgrid with an EPS is

1. Magnitude of voltage difference between Electric power system (EPS) and Microgrid (MG) should be small as possible ($< \pm 5\%$).
2. Phase angle difference between Electric power system (EPS) and Microgrid (MG) should be small as possible ($< \pm 1$ degree).

3. Slip Frequency difference between Electric power system (EPS) and Microgrid (MG) should be small as possible ($< \pm 0.1$ HZ).

While adding new generator to an ac grid, it is very important or necessary to do synchronizing initially. Because when we close the circuit breaker at that time short circuit current will produce that will harmful to the system equipment.

To start the parallel operation with an EPS can grouped into 2 types of the traditional technique. In Manual method as per synchroscope or synchramps or synch check relay operator controls the switching operation. Objective of an automatic synchronizing technique is to do synchronization process automation of micro grid. For adjusting voltage and frequency the active syncro technique uses control strategy on network based with multiple Generators.

Methods used for synchronization

- A. Synchronizing lamps
- B. Synchroscope

- A. 1. Synchronizing lamps
- A). Dark lamp method

Following fig. shows synchronizing with dark lamp technique, it involves voltmeter for measuring voltage magnitude of both elements. This method generally used in small rating generators.

In this method, generator prime mover which is to be synchronized started and operates up to rated speed. For maintaining equal voltage of alternator with bus, the field current flow controls in such way that it adjusts output terminal voltage of generator, flickering of three bulbs or lamps occurs at same rate of difference. If the phase is properly connected, all lamps will be bright and dark at the same time. If this is not the condition, then it means that the phase sequencs are not correct. In this two terminals of incoming generator should be interchanged for proper phase sequence. By frequency adjustment of generator to be synchronized it achieve very slow bulb flickering rate. By adjusting incoming generator voltage in dark instant in the middle closing of syncro switch operates. Since the voltage across the lamp varies from zero to twice of the phase voltage, the

lamps of suitable rating (usually two in series) must be used.

Advantages:

1. It is economically efficient method of synchronizing.
2. In this method phase sequence in proper sequence can be simply determined

Drawbacks:

1. It may possible that synchro switch may closed during half of rated voltage when phase difference may not close to zero, this may damage alternator by passing high current.
2. It may burn out the lamp filament..
3. It is not possible to determine which machine has high frequency by observing lamp flickering.

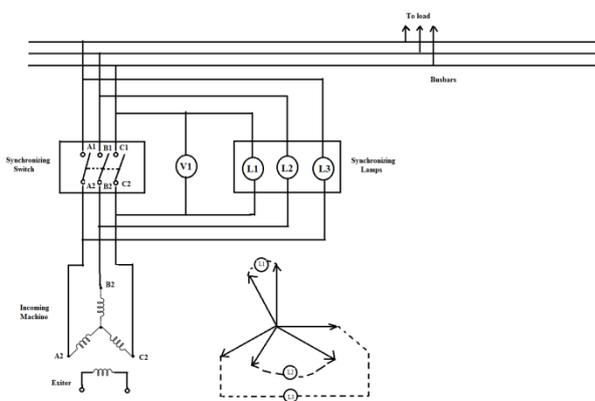


Figure 1. Circuit diagram of dark lamp method

B). Three bright lamp method.

In this method lamps connection are as below:

A1 lamp linked with B2. B1 lamp linked with C2. C1 lamp linked with A2. So now lamps get dark and bright together then it means sequence of phases is proper. During middle of bright condition, it is exact period of switching the synchronizing. Advantage of this method is it avoids confusion lamp failure by distinguishing brightest point easily.

C). One dark two bright lamp method

Synchronization with this method includes out of three lamps, two lamps are connected across two phases and in parallel phase's connected remaining one lamp. The connections are as below:

A1 is linked with A2. B1 is linked with C2. C1 is linked with C2. Then it tries to bring generator to its rated speed by starting prime mover. Now to achieve equal magnitude of bus bar and generator i.e. V_{a1} , V_{b1} , V_{c1} , and E_{a1} , E_{b1} , E_{c1} respectively by adjusting excitation voltage of generator to be synchronized. Then at the instant when two lamps equally bright that are cross connected and dark is straight connected lamp, this is correct time to close switch for proper synchronization. Under improper phase sequence all lamps gets simultaneously dark. Under this situation it is necessary to interchange the connection of generator terminals to reverse rotation. When voltmeter which is connected to straight lamp connection shows zero value then switch gets closed, since above significant voltage level extension of dark lamps occurs. It is condition where generator gets connected to bus bar and determined as load.

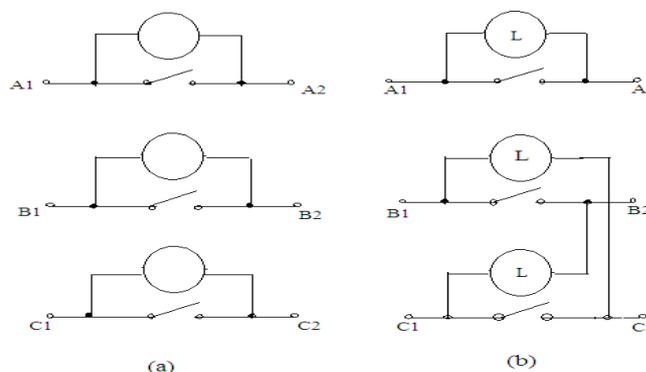


Figure 2. (a) Straight connection (b) Cross connection.

2). Synchronizing by a synroscope:

For observation of synchronizing parameters equipment known as synroscope is used. Synroscope gets input waveform of voltage from circuit breaker which is open from two sides. Synroscope work on frequency difference, it doesn't rotate, if it observes equal frequency of voltages and there is some difference in voltage w/f frequency, then it rotates proportional to difference value. According to current phase angle difference synroscope pointer points the same all the time.

“Scope” is what operator has to observe and take decision accordingly i.e. circuit breaker closing operation at exact instant for synchronization. In control room it is installed on sync panel with two voltmeters near, such that operator can easily observe scope of synroscope and voltmeters. Voltmeters show voltage

magnitude of both systems to be synchronized simultaneously.

Basic operation of synchroscope involves that it always reflects difference of voltage magnitude and near about 35 degree phase angle with stationary synchroscope. When similar frequency is on either side of CB, synchroscope does not rotate its pointer.

The phase sequence of the generator is generally checked carefully at the time of its installation. Synchroscope compares the voltage of one phase of the arriving machine with that of related phase of three phase system, the position of the needle of the synchroscope shows the phase difference between voltages of the incoming alternator and infinite bus. When the frequencies are equivalent, the needle is stationary.

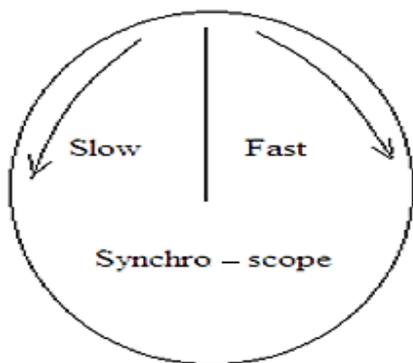


Figure 3. Synchroscope

When the frequencies are differing the needle rotates in one way or other. The direction of the pointer shows whether the incoming machine is running too fast or too slow, that is whether the frequency of the incoming alternator is high or low than that of infinite bus.

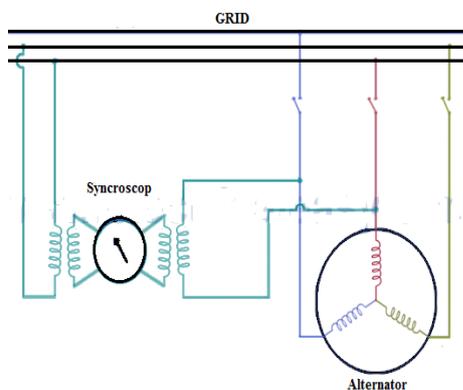


Figure 4. Synchronization of generator using synchroscope

Limitations of existing synchronization system with synchroscope:

In synchroscope method during synchronization process it produces some angular error while closing switch causes power swing and unwanted mechanical stresses on machine. Drawback of manual method is that, it is not possible to close switch at exact instant when difference of frequency are high. Synchroscope selects pointer with slow movement in such condition where operator is not expert in tools, where circuit breaker operation is slow (i.e. switch closing) and erratic. So to eliminate these drawbacks of manual synchronization method it is important that to use automatic synchronization system which is more accurate, faster and efficient.

So for avoiding unwanted mechanical stress and power swing which can damage equipment and reduces stability of system during synchronization process it is essential that all such element should be within specific limit as per rating plates during synchronizing.

Synchronization with help of synchroscope introduces power swing when circuit breaker closes with 15 degree out of phase with voltage even frequency difference very small .

2. Bhimashankar Sakhar Karkhana

Details of the power generation in the plant are:

The details of the power generated by the co-generation power plant are given in tables I and II for the 13MW generator unit and 6MW generator unit respectively.

Table I : Details of Power Generated and Distributed by 13MW Generator Unit

Total Generation of power from T,G set of 13 MW and 6 MW	18.000 MW
Sugar Factory and aux. power consumption	5.100 MW
Distillery, cogeneration unit and administration, colony.	0.900 MW
Total power consumption	6.000 MW
Surplus power to be exported to MSDCL grid	12.000 MW

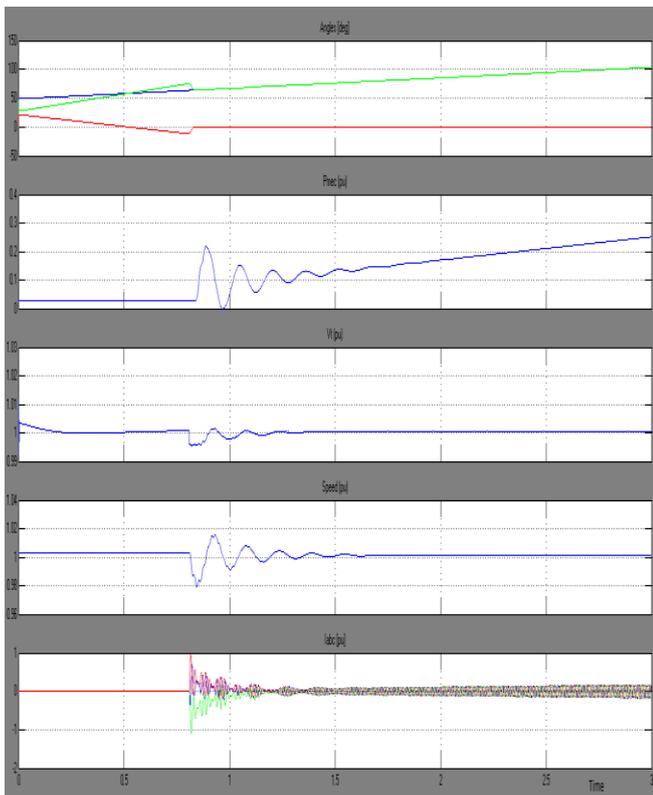


Figure 7. Results of conventional synchronizer

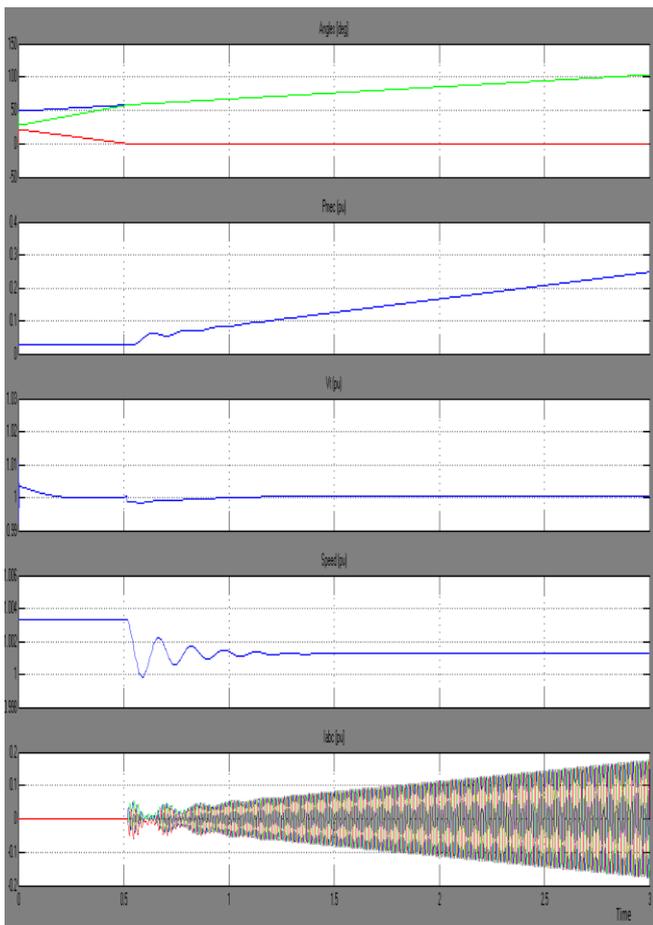


Figure 8. Soft synchronizer results

From both figures, it can be observed that oscillations for traditional synchronizer method at the time of synchronization are very large and maybe harmful and dangerous to the generator as well as grid. These transients at the moment of synchronization can be minimized with the help of soft synchronization method as can be observed in the latter figure.

IV. CONCLUSION

A novel approach for synchronization of micro grid with the main grid by automatically controlling the micro grid elements was presented in this paper. A soft synchronization method based on d-q method is ideally suited to minimize the transients during synchronization instant and whenever or wherever frequent connections and disconnections are required. The proposed technique of synchronization gives simple and efficient way to connect any additional generator to grid with minimum transients on system and helps to maintain stability. It also provides smooth linking process between alternator and grid. The d-q transformation which is based on the synchronization criteria as listed in this report along with signal conditioning and difference of phase-angle between micro grid and main grid is well suited for this test system. This paper also presents comparative analysis for the traditional and proposed soft synchronization methods through simulation results. The data from plant that was surveyed was used in the simulation study. The simulation results were validated for plant under consideration.

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