International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 04 Issue: 05 | May -2020 ISSN: 2582-3930

A Review on Generator Grid Synchronization Needs Effects, Parameters and Various Methods

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Abstract -Today, microprocessor and microcontroller based devices are preferred for improving reliability and efficiency of manual and automatic synchronizing systems. Synchronization is vital in overall power sharing process that it ensures quality, reliability and efficiency within the facility system. Synchronization is essentially all about matching Voltage, Frequency and phase of both generating unit and respective connected grid. This paper deliberates about need, effect and different technology used for synchronizing generators to grid. Whenever requirement of electrical power raises, extra power sources or generators need to hook up with respective grid. For quite one generator connected to grid, there are different techniques of synchronization which include manual and automatic operation of synchronization.

Key Words:Synchronizing grid, generator, grid stability, synchronisation

1. INTRODUCTION

Today's power system may be a huge and sophisticated electrical network as human requires big demand of electricity for various purpose. So to satisfy huge power requirement, power grids are forms. In power system differing types of generating sources and cargo centers are connected to balance the facility need at various locations. Synchronizing a generator or alternator to the ac network is extremely important task and will be done carefully. to attach additional generator to ac grid network, voltage magnitude and frequency of machine need to match with respective grid and phase of both generator and grid should be matched while connecting. In electric power system synchronizing failure may introduces:

Synchronization failure may affect system stability by producing voltage deviation, transients and unnecessary oscillations within network which disturbs power grid stability and reduces overall efficiency of system.

Mechanical strains thanks to sudden speeding up and speeding down, may harm respective generator and therefore the first cause .

High currents flow through system which may damage the windings of power transformer and respective generator permanently. Generator may get disconnected from taking load and system gets suffering from unbalanced parameters.

Due to increasing abnormalities within system total black out May occurs which pack up all power grid .

So, it's vital that each one generators connected to power system should proper synchronized with grid parameters.

Generally, design control systems contains generator synchronizing panel. The synchronizing panel is meant such how that it shows frequency, voltage magnitude, phase , slip in order that operator should take necessary action to regulate governor system and excitation system parameters and after matching voltage, frequency and phase parameters, closes the synchronizing breakers. This process is usually made by using automatic synchronizing system and extra stand by manual system as backup system. Today, synchronizing methods developed by using various electronic components which give reliable and efficient operation of synchronizing. Using electronic component like microprocessor and microcontroller devices automated and manual synchronizing process can improve considerably. By using advance communication media like fibre optic cables, Input output units can hook up with automatic synchronizing system which is found at room. This reduces various errors occurs during synchronizing and eliminates long voltage transformer circuits runs. Computer based synchronizing system further provides addition information to operator whenever, whenever generator connects with grid. This technique consist computer controlled soft syncroscope which makes synchronizing more reliable and effective. we'll see basic synchronizing techniques then automatic synchronizing systems.

2. OBJECTIVES

Study the basic concept of Synchronization in Electrical power System. To study effects of poor synchronization on power system.

To study different components comes under grid synchronization.

A. Phase Sequence

B. Voltage Magnitude

C. Frequency

D. Phase Angle

To study condition for proper synchronization. To study different method of synchronization.

A. Three Dark Lamp Technique

B. Two Bright, One Dark Lamp Technique

C. The Synchroscope Technique

3. SYNCHRONIZING PARAMETERS

For proper synchronization of generator and ac power system , basically four parameters need to consider: Sequence of phases of generator and grid.

Voltage Magnitude of both. Frequency level.

Phase Angle of every phase.

A. Phase Sequence

it's important that, the three phases of both generator and ac network grid should be in same sequence for correct synchronizing. Generator alternator has three 120° degree apart phases which may be delta or star connected. This phase sequence should be perfectly matched with grid phase sequence for proper synchronization.

B. Voltage Magnitude

Every generator is meant to offer specific output voltage magnitude. While synchronizing generator to respective grid, voltage level should satisfy sine qua non during which the voltage magnitude (sinusoidal) generated by must be like the magnitude of the grid voltage.

C. Frequency

Generator produces electricity at certain specific frequency designed by manufacturer as per requirement. The generator frequency should be adequate to the frequency on which grid operating. Frequency matching is extremely important so as to scale back post synchronization transients on overall system. Generally Syncroscope is employed to think about frequency parameter.

D. Phase Angle

Similar to phase sequence, the phase also vital parameter of generator synchronization to grid. phase is an angle between the voltage generated by the generator and therefore the voltage of grid. This phase difference must be zero while synchronizing a generator to grid. From observation of peaks and 0 crossing incidence of the sinusoidal waveform (i.e. 0 to 360°), the phase are often measured.

4. SYNCHRONIZING CONDITIONS

For correct synchronizing operation to connecting a generator to existing power system , following conditions must be satisfied: Sequence of Phase should be same.

Voltage magnitude of generator and grid should be equal.

Frequency of generator and grid should be same.

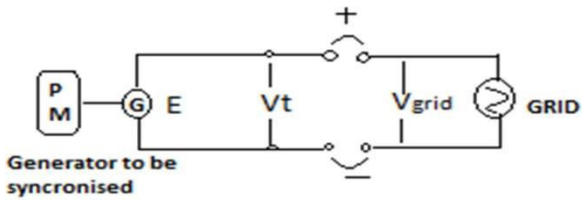


Figure 1 – Generator and Grid Synchronization.

A. The Phase Sequence

The sequence of three phases or rotation of the three phases of generator which be connected in star or delta configuration must be an equivalent as three phases of the electrical system i.e. ac grid network is to be synchronized. There are only two possible sources of in sequence. During maintenance the generator or transformer terminals could be interchanged or the voltage transformer leads are often interchanged.

B. Voltage Magnitude

The voltage magnitude grid should be adequate to the generator voltage magnitude. If the 2 voltages aren't an equivalent and every one other conditions are met albeit , synchronization may fail. Big MVAR flow causes, if there's a difference between generator and grid voltage magnitude. If the grid voltage is a smaller amount than the generator voltage still it linked to the ac grid then generator gets overexcited and it flows more MVAR though system. If there's voltage difference such , the grid voltage magnitude is quite the generator voltage magnitude and if under this condition, generator connected with grid then the generator will behaves under-excited so it'll take up more MVAR from system.

C. Frequency

The generator frequency and voltage frequency ac grid network should be same for correct synchronization.

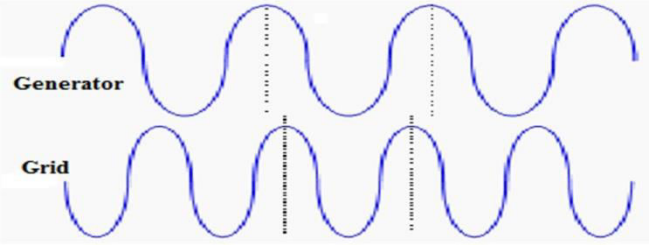


Figure.2 Generator slower than grid.

Thesyncroscope rotates rapidly counter clockwise. just in case of breaker of the generator accidently closed it'll cause the generator out of step with the ac grid system is to be connected. After this example generator will acts as motor and grid tries to require it up to hurry . Due this, it'll harm the generator because slipping of stator and rotor poles occurs. If generator were faster than the grid then similar problem will observed with system.

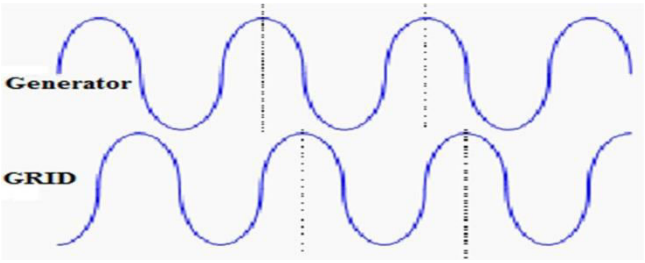


Figure 3- Generator and grid matching speed.

The generator and grid are matching speed is shown in figure 3.At same speed rate zero crossing and peak point of voltage sine wave occurs. In figure 2 it appears as a non-rotating syncroscope because phase and therefore the grid exist among them. At this instance, if a generator breaker gets closed, the grid system will pull generator into step. Under this example stress on stator and rotor will increases, with high inrush current flow through generator. Thanks to this generator may damage permanently. With same forces, a number one generator will attempt to take power into grid network instantly. So it's very essential to match exactly waveform of generator and grid.

5. SYNCHRONIZING TECHNIQUES

A. Conventional Techniques

There are various techniques that are used for generator or alternator synchronization, here explained various schemes to attach the generators to the grid. Following are synchronization schemes:

Three Dark techniques

Two Bright, One Dark technique The Synchro scope technique

These techniques are most preferred in old days but thanks to manual operation and fewer accuracy this system needs a really skilled individual also these methods have less reliability and security. So, now days generally Synchro scope technique and microprocessor or microcontroller device based synchronizing systems are more used for the automated synchronization operation of the generators. Because using microcontroller base systems generator synchronization becomes far more reliable and easier to work than conventional methods.

1) The Dark Lamp Method:

The three-dark method for synchronize two three-phase generators. Generator-2 is connected to the load circuit. Generator-1 is to be connected in parallel with generator-2.Three bulbs or lamps are connected between generator Generator-2 and therefore the load with double the output voltage to the load as shown in figure 4. Following effects are observed when two generators operate:

Depend on the difference of two generators frequency rate the three lamps will glow and leave together.

If the Generators aren't linked within the correct phase order and out of phase. Then depend upon the difference of two generators frequency rate the three lamps will glow and leave but not in unison. For correct phase sequence it's needed to exchange any two results in generator G1. Until all lamps glows and leave in unison, the generators aren't paralleled. The lamp technique has better simplicity of process.

By slightly adjusting the speed of generator-1, generators frequency are often equalized. This may glow synchronizing lamps and leave with lowest rate. After out the three lamps, at now, instantaneous electrical polarity is same of the generator-1 as generator-

2. Now voltage magnitude of generator-1 is same as generator-2 and also in phase with one another. At now synchronizing switch are often closed to provide power from both generators to grid connected loads. In order that both generators can provide the availability to grid connected loads. This will be considered as two generators are in synchronism with grid system as per three lamps dark technique.

Even though this method is straightforward and price effective, it's some demerits. Across lamp it's going to have high voltage, albeit its dark burned out. Thanks to this it's going to possible that paralleling connection may switch, even there's large difference between generators voltage and phase.

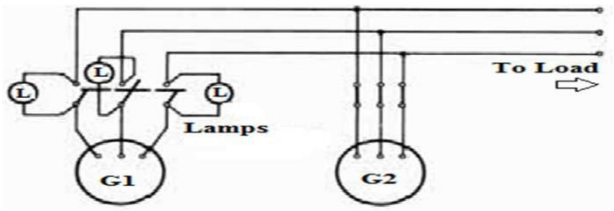
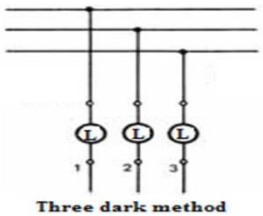


Figure 4: Synchronization of generators by 3 dark lamps method

2) Two Bright, One Dark Method: during this technique, Generators are connected then any of two synchronizing lamps connection makes crossed. After this proper phase sequence of generators are to be checked. Figure 5 A shows the connections for the right phase sequence by the three dark techniques. For generator synchronization by two bright, one dark method, necessary lamps connections is shown in figure 5 B. during this method, if lamp-1, lamp-2 becomes bright and lamp-3 becomes dark then generators get synchronized. The synchronizing instant is when out of three lamps one lamp is blowing dim and other two are brighter. At this exact instant synchronizing switch are often closed. So it's very easy to operator to make a decision when to shut the synchronizing switch by observing the sequence of synchronizing lamps light. For knowing the speed of generator (i.e. too slow or too fast) which is to be synchronized is set by observing the sequence of bright lamps.



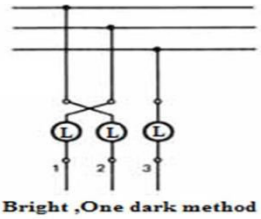


Figure.5 (A) The Three-Dark Technique; (B) Two-Bright, One-Dark Technique

a) Demerits of Synchronization System Using Lamps' Method Are

i. Operator should be very skilled for giving correct judgment of Synchronization instants by using incandescent lamps.

ii. By using this system it's impossible to understand i.e. generator is slow or fast.

iii. For top voltage generators, extra apparatus like step down transformers needed for lamps, because lamps are generally of low ratings.

1) The Synchro scope Method:

For knowing exact instant to closing synchronizing switch a syncroscope device is employed . A pointer rotates on the dial in syncroscope. If the generator is running slower then pointer rotation direction are going to be in anticlockwise and if generator is running faster, then pointer rotation direction are going to be in clockwise. When the pointer of synco scope is exact straight upwards it's correct movement of closing the switch of synchronization. As we all know in lamps method synchronization effectiveness generally depends on operator experience, decision and skill. The three lamp technique is straightforward and price efficient but during this method it cannot provide information about frequency i.e. it's higher or lower for synchronizing generators. So for this purpose syncroscope device used which informs about incoming generators frequency whether it's lower or higher. for giant voltage systems, lamp technique can't be used so generally synchro scope technique is preferred. In its construction it consist one moving vane and three coils. The coils of syncroscope are connected to the generators and bus bar which is to be synchronized and pointer connected to moving vane. the utilization of voltage transformer for measuring the difference in voltage, the pointer will rotate in clockwise direction or anti clockwise direction and after speed of incoming generators becomes equal the pointer, it'll stop at upward vertical direction and relays switched to attach the generator to the grid bus bar. Figure 6 shows below, the pointer move in anti-clockwise or clockwise direction and after incoming generators speed becomes adequate to that of bus, relays are going to be closed for synchronizing.

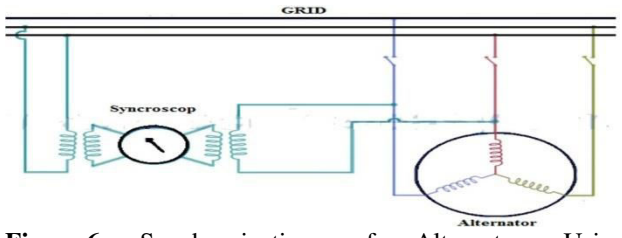


Figure.6 Synchronization of Alternator Using Synchroscope

The pointer of Synchro scope will continuously in motion if the 2 voltages phase is different. If the incoming generator is slower then it'll move to slower point and if then incoming generator is quicker then it'll move towards the faster point and after equal frequency of generator and grid bus bar pointer will stop moving. this example is for closing synchronization switch.

A synchro scope is preferred for synchronizing two generators because it informs very correctly the precise synchronism instant. Connection of syncroscope is across just one phase thanks to this reason it can't be used safely. It are often connected only after checking proper phase rotation and testing

the generator. For determining proper phase rotation Synchronizing lamps could also be used. In various applications, the generator connections to the grid through a paralleling switch are permanent. In these case phase rotation checking aren't essential. For synchronizing generator to the grid only syncroscope instrument is required in these cases. For countercheck system, a group of bulbs are often used for synchronization purpose.

Figure7 Synchroscope meter and synchronizing indicator

6. SYNCHRONIZING METHODS

Nowdays followings three most used methods are used for generator synchronizing:

Manual synchronizing method

Manual with permissive relay (synch check) synchronizing method Automatic synchronizing method.

A. Manual Synchronizing

Manual synchronizing method is usually used on a spread of generating stations. In manual synchronizing system basically it includes component like synchronizing lamps or lights, a synchro scope instrument, metering devices and a breaker to shut switch at right instant.

In manual synchronizing method operator Controls generators voltage magnitude and speed and operates the relays or breaker at the precise synchronism instant. The most advantages of this technique are simplicity and price effectiveness. Any sort of generator are often synchronized by an operator is feasible and straightforward monitoring the facility plant is feasible in manual method.

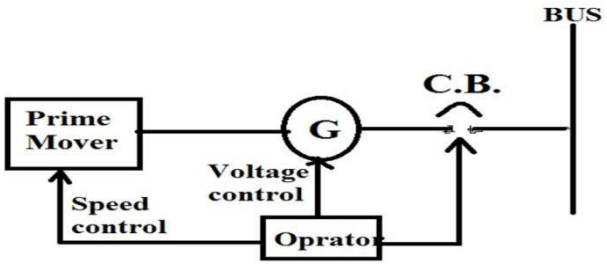


Figure.8 manual synchronizing.

B. Manual with Permissive Relay

This synchronizing method is analogous as manual method but it's additional sync-check relay (i.e. ANSI/IEEE Device 25).Main purpose of the sync-check relay is to offer copy to shut the generator breaker for synchronization which is set by operator. Closing of Breaker takes place only after sync-check gives permission to shut, when synchronizing parameters i.e. voltage, frequency and phase and sequence are satisfied for correct synchronization. With this extra facility the operator can close the breaker confidently. This method provides more efficiency and errorless synchronization operation.

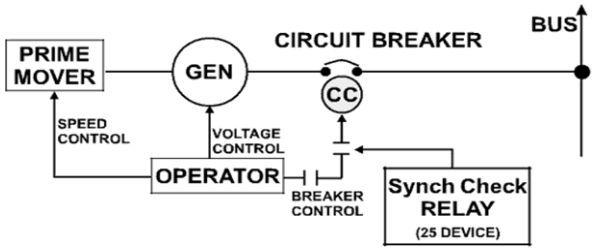


Figure.9 Manual synchronizing with synch check relay

C. Automatic Synchronizing

As name indicates, this synchronization method is an automatic synchronizing process, the automated synchronizer (ANSI/IEEE Device 25A) is capable to watch and control frequency, voltage and phase , and it also provides improvement in respective signals for voltage matching and frequency matching with grid parameters and after satisfying all conditions it'll provides signal to the breaker to shut contact at correct instant.

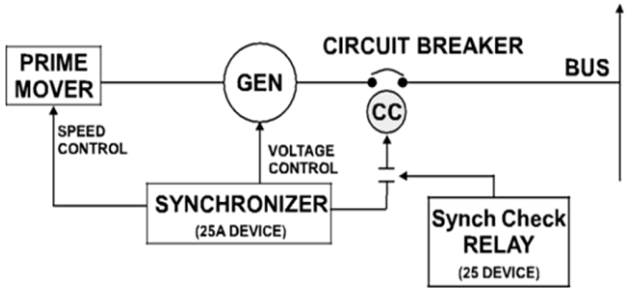


Figure.10 Automatic Synchronizing

7. AUTOMATIC SYNCHRONIZERS

A. Phase Lock Type Automatic Synchronizers

This is one among automatic system for synchronization of generator with grid. The synchronizer which is phase matching type is automated system during which it gives a breaker closing angle window and voltage magnitude approval. During this system if a generator is within specified operation window, the synchronizer system activates a relay and initializes the breaker closing process at correct instant.

The phase lock type synchronizer uses the concept of improving the signals that are useful to work governor system and automatic voltage regulation system. These signals are provided by synchronization system until the all synchronizing parameters are perfectly matched with grid parameter. this sort of synchronizer can provides respective control signal to governor system to regulate the speed of generator to match various parameters with grid.

As the control signal controls the first cause output which controls speed of generator. When the voltage reaches an accurate magnitude with reference to grid system it'll initialize the synchronizing switch to attach generator to grid. The synchronizer senses frequency, phase and bus voltage of both generator and therefore the grid

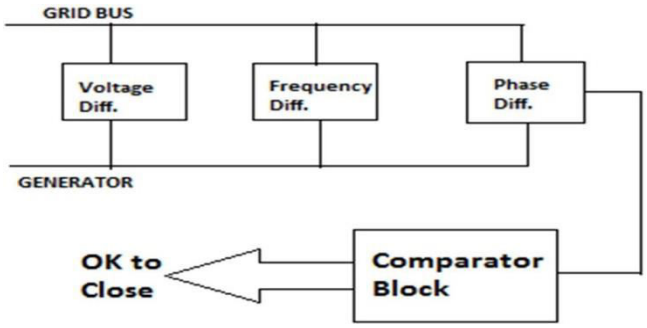


Figure.11 Compare Phase Angles

The synchronizer senses frequency, phase and bus voltage of both generator and therefore the grid

The synchronizer measures a difference between the generator and grid for voltage, frequency, and phase and if any difference found by system it'll generate the acceptable signals to correct that difference and to match all parameters with grid. This automatic synchronizing system is meant with the assistance of using various electronics component like comparator; microprocessor/microcontroller etc.

B. Advantages of Automatic Synchronizer

1) Frequency/Phase Correction Option: Automatic synchronizing system designed with electronic components which can provide comparative values and appropriate corrective signals. For frequency correction bipolar d-c correction output signals provide to the governor until the generator frequency is corrected to within ±3 Hz of the grid bus frequency. After ±3 Hz difference is achieved, the output

of system is proportional to the frequency difference. Then synchronization system contacts output correction signals and if the phase is bigger than the setting of front panel then the output contact will closed. The contact will open only after phase is a smaller amount than the setting of front panel setting.

2) Option For Correction Of Voltage: Automatic system provides voltage correction facility. Now day's generally generating units have automatic voltage system. By using this idea of AVR it'll provide the corrective signals to the system to match voltage magnitude of generator to the grid voltage. Process of the voltage matching selection is same as frequency or phase matching, but during this correction signal wont to regulate generator voltage magnitude. When the automated synchronizer gets in-tuned with output voltage matching and it'll wait until voltage difference of the

Matching and it'll wait until voltage difference of the generator and therefore the grid brings within particular limit the switch contact remains closed.

3. Option of Dead Bus: the automated synchronization system has the dead bus option during which it allows the generator to attach to the bus bar albeit the bus may very low or inactive. This is often very useful characteristic of automatic synchronization system to supply emergency reserve systems that require the primary connect generator up to the dead grid bus

8. FUTURE TRENDS

By watching the amount of papers published and various article on grid synchronization technologies in recent years, it's easy to conclude that Synchronization of generator study and improvement activities are experiencing an explosive rate of growth. Although this paper has focused on concept of synchronization, need of synchronization, effects of poor synchronization on system, synchronization parameters and conditions and different methods of synchronization, there's other research and development in related areas, like more reliable and transient less synchronization technique..

9. CONCLUSION

Wehave studied need of synchronization in electric power system, various parameter and conditions of synchronization, different methods of synchronization and therefore the automatic synchronizing process and explored a number of the considerations involved. We've tried to determine some guidelines for the choice of the right synchronizing system for the appliance.

ACKNOWLEDGMENT

I am highly grateful thank to my guided Prof. Prasanna D Bhardwaj for his constant intellectual support within the sort of his innovative ideas and valuable guidance. i'm also grateful to Dr. D.S. Bankar (Head of the Department) and Asst. Prof.Holmukhe (M.Tech Co-ordinator) for his or her guidance. We place on record my extreme indebtedness to them for providing us proper guidance at every step.

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Dabowsa Supervisors Prof. Dr. Mohammed Abdelati& Dr. Iyad M. Abu Hadrous A Thesis Submitted in Partial lfillment of the wants for the Degree of Master of Science in EE June 1432-2011 The Islamic University of Gaza Deanery of Graduate Studies Faculty of Engineering EE Department.