Comparative review of analogue and digital Synchroscope in India used for synchronization of power alternators during parallel operation.

Mr. Akash Holmukhe[1], Prof. Bhushan Save[2], Mr. Anuj Kap[3], Mr. Lalit Sonar[4]

[1,3,4]B.E. Student, Electrical engineering, VIVA Institute of Technology, Maharashtra, India
[2]Assistant Prof & HOD, Dept. of Electrical Engineering, VIVA Institute of Technology, Maharashtra, India.

Abstract - *Synchroscope is an important device used in the process of synchronization of alternators at generating stations. Synchronization of alternators is important to connect the two or more alternators in parallel. There are commonly three methods used for synchronization i.e. Three Dark Lamps method, the Two Bright One Dark method, and Synchroscope Method. Where the synchroscope method is frequently used for better accuracy. Synchroscope used for this process is an electro-mechanical and analog type and requires manual operation and other measuring devices also. So, we tend to use the digital synchroscope. This single device shows all parameters on the display and also gives the option for automatic operation. It is reliable, easy to use, easy to monitor, and cost-effective.*

Key Words: synchronization, digital synchroscope, parallel operation, alternators, synchroscope.

1. INTRODUCTION

Nowadays due to the high-power demand, the parallel operation of two or more alternators are the need in the electrical power system to achieve the demand. Also, there are more advantages of using the parallel operation of alternators like a reliable, flexible, expandable, cost-effective and providing good quality and continuity of power to the consumers. For this parallel operation, we need to synchronize the alternators. If proper synchronization is not done, then the alternator can be damaged. The methods used for synchronization of alternators are three dark lamps, two bright one dark lamp, and the synchroscope method used for synchronization. Where the synchroscope method is used frequently nowadays. At a time of synchronization, we have to match parameters such as a voltage, frequency, phase sequence, and phase angle of an incoming alternator and running alternator or bus bar, where we have to use a separate measuring instrument like voltmeter, frequency meter, phase sequence meter, and synchroscope to monitor the individual parameter for performing the parallel operation, which increase the cost of the system and synchroscope used in this method is analogue type highly sensitive, less accuracy, required more power to run. Now that the world is becoming digital, we should prepare the digital system for parallel operation. This paper accentuates the digital type synchroscope. It will be more accurate, less sensitive, and lightweight. Which will show all required parameters on the single screen, so no need to use individual instruments for measuring purposes. This will automatically reduce the cost of the system and also reduce the complexity of the system. The relay terminals are also provided which gives the option to the operator for automatic or manual operation of synchronization. While the system is set to automatic operation, the relay gives the signal to the circuit breaker to close the circuit, and if there is any mismatch condition in parameters the circuit breaker will open. So, the use of this device increases the accuracy and easy operation of the synchronization of alternators.

In a power station one or more alternators are connected in parallel. This parallel operation is important for reliability in a parallel system if a single alternator fails or is taken out for maintenance the others will keep the system active and maintain continuity. Also, the requirement of the load may vary throughout the day. So, to meet the demand of load more alternators can be added. Efficiency can also be maintained if alternators operate at their load rating.

Alternators operating in parallel can give a bigger load than a single alternator. So more alternators in the system can increase the capacity of the system.

1.1CONDITION FOR SYNCHRONIZATION

At the time of the synchronization process, we have to make sure that four parameters align between the alternators.

1. Phase sequence: the three phases of an incoming alternator and running alternator must have the same phase sequence.

2. The voltage magnitude: The voltage of both alternators must be equal.

3. The frequency: The frequency of both alternators is also equal because unequal frequency can create an unstable flow of energy and this instability may lead to damage to the equipment.

4. Phase angle: The phase angle of an incoming alternator and running alternator must be zero.

2.SYNCHRONIZATION METHOD FOR PARALLEL OPERATION OF ALTERNATORS

2.1 Three dark lamp method

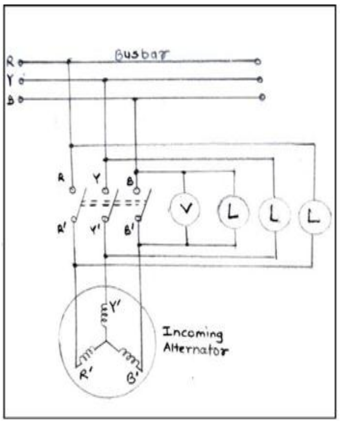

Fig 1- Three dark lamp method

Three lamps and one voltmeter are used to check the conditions for paralleling operation of the incoming alternator and running alternator. The figure1 shows the three-dark lamp method. Generally, this method is used for low-power machines.

The incoming alternator is started and brought up to its rated speed. Then the field current is adjusted to make the incoming alternator voltage equal to the running alternator or bus bar voltage. If the phase sequence is proper then the lamp will be dark and bright at the same time. Lambs will flicker at an equal rate if the frequencies are different. So, the frequency is adjusted until the lamps stop flickering or flicker at a slow rate. After satisfying all conditions the synchronizing switch or circuit breaker is closed in middle of the lamps dark period.

2.2 Two bright one dark lamp method

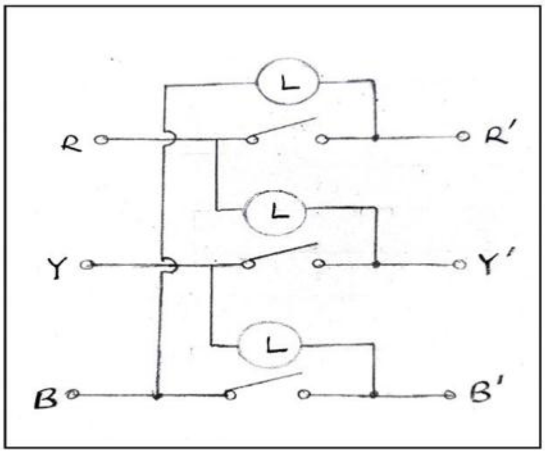

Fig 2- Three bright lamp method

In this method two Lamps are cross-connected between two phases and one is connected between the corresponding phase that is R is connected to R', Y is connected to B', and B is connected to Y' as shown in the figure 2.

The synchronizing switch will be closed when the straight lamp is dark and the other two cross-connected lamps bright equally. If phase sequences are incorrect then all lamps will be dark. Also, the voltmeter is connected across the straight connected lamp since lamb can be dark at certain low voltage. So, when the voltmeter shows the zero reading then only synchronizing switch will close.

2.3Three bright lamp method

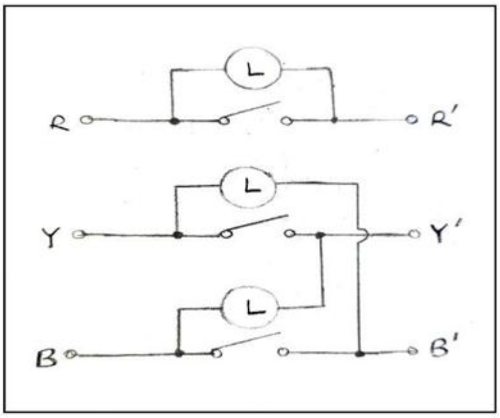

Fig 3- Two bright one dark lamp method

Similarly in this method, three lamps are used only the connections are different. It is connected across the phases that R is connected to Y', Y is connected to B', and B is connected to R' as shown in fig. Identification of conditions for parallel operation is the same as the previous method only the different synchronizing switch is closed in a middle of a bright period of the lamp. The advantage of this method is the brightest point is easier to identify than the middle of the dark period.

2.4 Synchroscope method

- What is a synchroscope?

  It is an instrument that indicates the two alternating currents of alternators are in exact phase relation in parallel connection. It shows the phase angle between the machines and also defines the operating speed (slow or fast) of the incoming alternator.

Fig 4- Synchroscope

- Working principle

The synchroscope consists of a stator, two phases, and a rotor. A Two-phase supply is provided by the alternators. These two phases are synchronized together then the third phase is automatically synchronized. The supply from the running alternator is given to the stator of the synchroscope and the incoming alternator supplies the rotor of the synchroscope. The phase shift between the supply gives a difference between the frequencies. When the frequency of the alternator is different the device starts operating to get the desired parameters. When the status and rotor frequencies are the same, the rotor stops rotating and remains stationary. If the supply frequency is having a large difference the rotor rotates at a higher speed and when the difference is minimum the rotor speed is reduced. When the frequency and phase angles are zero the pointer stop rotating and points towards the zero position. Then two systems are ready to connect safely.

3.TYPES OF SYNCHROSCOPES

1.Electrodynamic type

2.Moving iron type

3. Electronic synchroscope

4. Digital synchroscope

1. Electrodynamic type

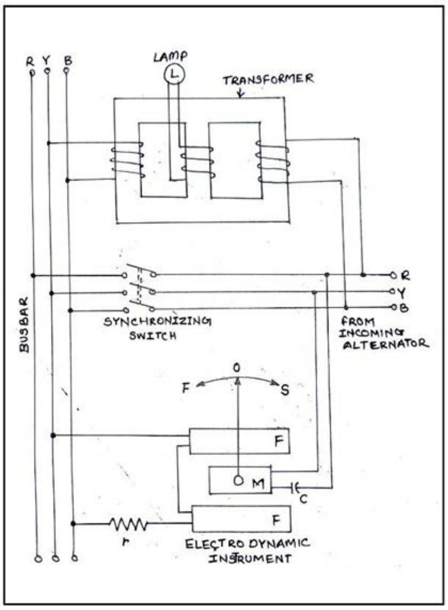

Fig 4- Electrodynamic type

This type of scope is also called a Weston type of synchroscope which includes an electrodynamic device and three limb type transformers. The winding on one limb is connected with a running alternator or busbar and another outer limb winding is connected to the incoming alternator and the central limb is connected to the lamp. The outer limbs produce two fluxes, flowing through central lines. This flux induces on emf in central limb winding. When the voltage of both alternators is in phase, the two fluxes in the central limb are added and induced emf in the central limb and the lamp glows with maximum brightness. when voltages are 180 out of phase flux is zero and no emf induced and thus the lamp does not glow. If the frequency of both alternators is different, the lamp will flicker. But it will not indicate whether the alternator is slow or fast. So, an electrodynamic instrument is provided.

Disadvantages

- This instrument has a low torque/weight ratio and so low sensitivity.
- Frictional losses are there, also expensive than the moving iron type synchroscope.
- The power consumption of this instrument is high.
- Screening of moments against the stray magnetic field is essential.

2. Moving iron type

Moving iron type synchronous scope consists of a fixed coil of two parts. Also, there are two iron cylinders mounted on the spindle and separated by spacers. The cylinders are excited by two pressure coils and connected to two phases of the incoming alternator. The pointer is attached with the spindle and moves over a dial marked fast and slow.

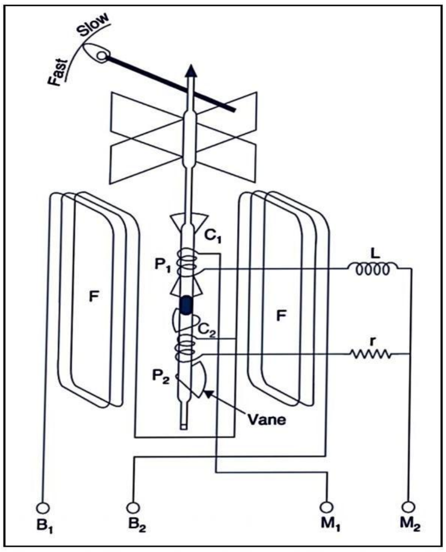

Fig 5- Moving iron type

Disadvantages

- This instrument suffers from error due to frequency change hysteresis and stray losses.
- Its scale is non uniform so accurate reading is not possible.
- Also, the reading of instruments is affected by temperature variation.

3. Electrotonic Synchroscope

Fig 6- Electrotonic Synchroscope

The operation of this device is the same as the above synchroscope instead of moving the pointer there is an incorporated circle of LEDs is used. This led is glowing sequentially in a clockwise or anticlockwise direction at a variable speed which indicates the difference in frequencies of an incoming and running alternator. Waves synchronization is done the 'SYNC' led will glow. This device is based on electronic components so, no moving parts are there. Also, power consumption and losses are low. The LEDs is it is easily visible to the operator in dark places.

4. Digital synchroscope

This synchroscope is based on a microcontroller, therefore there are no moving parts involved in it. This device shows the actual value of voltage, frequency, and phase angle difference on a single display in numerical form which reduces error and increases accuracy. So, there is no need to use separate instruments for measuring voltage, and frequency parameters which also reduces the cost of the system. Digital type also gives the option to the operator to make the process automatic. There are no friction or iron losses because of an electronic-based device the power consumption of this device is also very less.

Fig 7- Digital Synchroscope

4. CONCLUSIONS

As we know the world is going towards digital things and automation. Synchroscope is the most important part of the synchronization process. The Digital synchroscope has many spectacular features that can replace conventional technologies. Provide a high accuracy level and are easy to handle and monitor.

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