Synchronization of Alternator to Grid

1 Aim of the Experiment

The aim of this experiment is to study the process of synchronizing an alternator to the grid.

2 Background

A standalone alternator is of limited use. Connecting several alternators together allows us to have loads that substantially exceed the capacity of any single machine. A network is thus formed. When it is desired to augment the capacity of the network, we can then connect, or *synchronize* another generator to it. However, the process is not as simple as closing a switch since certain conditions have to be met before one can connect running alternator to the grid. What are the conditions under which this can be done?

Once it is synchronized, the machine at that point of time is not involved in any power transaction. One may then make it send power to the grid by supplying mechanical power or make it draw power from the grid by making it deliver mechanical power. The power factor at which the electrical power is handled by the machine depends on the excitation.

3 Procedure

The alternator has to be run by a dc machine. The dc machine therefore acts as a motor and the synchronous machine as a generator. The circuitry required to run the dc machine as a motor is already familiar to you by now.

The virtual instrument (vi) to be used for synchronization would be loaded in your computers and is called "synchronization.vi". This virtual instrument panel is designed to show you the phasor diagrams of the grid side and the machine side. There are three LEDs that glow if frequency error, phase error and rms voltage error are within limits. Synchronization can be done if all three glow.

The vi further shows R & Y phase voltages of the generator and in another plot R & Y phase voltages of the grid. The similarity of phase sequence can be scertained from these. The vi also shows one plot superposing R phases of both generator and grid. This is a means of verifying the phasor diagram and LED information.

In order that the vi works properly, the following inputs need to be given.

Quantity	DAQ bench terminal
V_r of gen	AI1
V_y of gen	AI2
V_b of gen	AI3
V_r of grid	AI4
V_y of grid	AI5

Please make sure that the required data for the vi through the required data ports is provided. Ask your teaching assistant in case of doubt.

3.1 Synchronization

It is *very important* to recall the conditions for synchronization. What are they?

The virtual instrument, when connected properly, would show the phasor diagrams rotating. The RYB rms vectors would be rotating as you would expect from the normal theory of ac circuits. With the alternator excited, there would be two sets of phasors — one belonging to the machine and one to the grid. For synchronization, their magnitudes have to be equal, they have to rotate in the same direction and the corresponding phasors have to (nearly) overlap. Note that *corresponding phasors* have to overlap; this in turn requires that in order that the phasor diagram makes sense, proper connections have to be made to ensure phase compatibility.

How would you change the magnitude of the phasors? Can the grid side phasor magnitude be changed? Can the machine side phasor magnitude be changed?

Close the switch between the machine and grid at an appropriate time. What happens to the phasor diagrams after that?

3.2 Operation as a synchronous generator

With the machine synchronized, note down the field current and armature current (of both machines). Now change the field current - increasing and decreasing (not reversing it). Take care not to exceed the rated armature current of either machine. Note down the variation of alternator armature current with field current. What is the power supplied by the alternator to the grid? Bring the alternator field to the status when it was just synchronized.

In the dc machine armature side, you may find that the armature resistance has not been cut down completely during the process of synchronization. Use that to increase the voltage supplied to the dc machine armature. What do you expect to happen? What are the armature currents of both machines?

Now repeat the exercise of varying the field excitation at this level of armature voltage supplied to the dc machine.

Note down also the power factor variations when the field currents are changed.

4 Calculations

Plot the variation of (a) armature current as a function of field current and (b) power factor as a function of field current.