

Application Note

Enhanced Sync-Check Operation Using the Basler ES-25 Relay

The ES-25 relay provides enhanced sync-check operation in a low-cost industrial relay. When closing a circuit breaker to connect a generator to an already energized circuit, it is important to match both the phase angle and the voltage. The goal of a sync-check is to minimize transient disturbances and prevent damage to both the system and to the generators. Many industrial relays perform a sync-check by measuring the absolute voltage or phasor voltage difference between the bus and the generator. The microprocessor-based ES-25 relay measures the voltage and the angle



ES-25 Sync-Check Relay

independently. Independent voltage and angle controls make it easier to achieve settings that protect the system and the generator, allowing quick and easy synchronizing.

A difference measured between the generator and the bus can occur for two reasons. One reason is the voltage magnitude of the generator and bus. For example, assume both the generator and bus voltages are in phase. If the bus is 126 volts while the generator is 120 volts, there is a 5% voltage difference between the generator and the bus. Another reason is the angle between the two voltages. For example, assume both voltages are 120 volts but are slightly less than 3 degrees apart. The measured voltage difference will be about 6 volts or 5%. An example of using the absolute voltage measurement method is described next. Figure 1 shows a generator voltage of 120 volts and 0 degrees. The circle represents a voltage difference set to 5%, which as described later, is a common recommended setting. In this example, the bus voltage is at 115.9 volts and 2.1 degrees out of phase with the generator voltage. The generator and bus are at the limits of acceptable synchronizing based on the 5% setting. If the voltage magnitude of the generator increases or the angle between the bus and generator voltage increases, the synchronization parameters will not be met because the difference will be greater than 5%. Using the absolute

voltage method to determine synchronization, though it may seem valid, may not be the best method because it may result in making a generator unnecessarily difficult to synchronize.

The *IEEE Guide for AC Generator Protection* (IEEE C37.102) identifies typical allowable synchronism angles to be ± 10 degrees and typical allowable synchronism voltages to be a difference of 0% to 5%, not to exceed 5%. This is a recommendation that has become common across many generator application papers and guides. It is no coincidence that these are also the limits identified in IEEE generator standards C50.12 and C50.13.

Using the single set point, absolute voltage setting method, the commonly recommended settings are not achievable. In fact, it is difficult to get very close. In the example above, the voltage magnitude difference is about 3.4%. With this difference, the angular difference must be equal or less than 2.1 degrees to be within the 5% setting. If the voltage magnitude could be matched exactly, the maximum allowable angle would be about 3 degrees. This limits the ability to close the circuit breaker on machines that are designed to close at angles up to 10 degrees. As a result, there may be some difficulty synchronizing as the operator tries to match the angular difference to a level that is not necessary. By setting

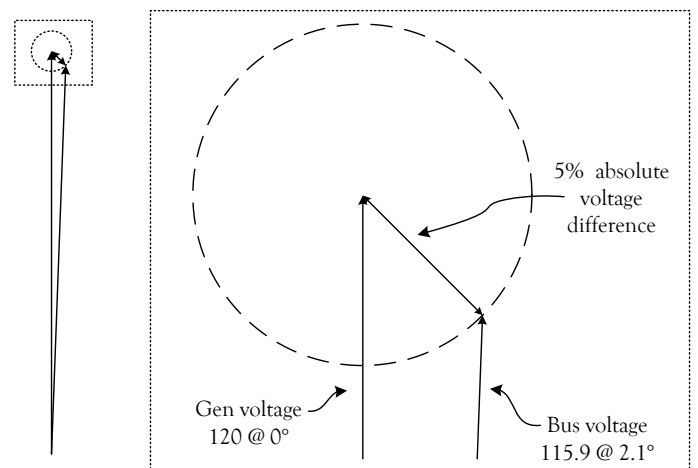


Figure 1 - Absolute Voltage Measurement Method

the difference to a level that will allow an angle of 10 degrees, a voltage magnitude difference that is over 17% of nominal would be allowed. This is not acceptable for the generator or the system. With modern regulators making it easy to match voltage very accurately, there may also be a desire to reduce voltage mismatch to reduce var flow at the time of circuit breaker closure. If the voltage difference is reduced to 3%, it becomes increasingly difficult to close the circuit breaker, as the acceptance angle is reduced to just 1.7 degrees.

The ES-25 relay evaluates voltage angle and magnitude independently while maintaining low cost and a small

footprint required by industrial applications. Figure 2 shows the synchronization acceptance window relative to the generator voltage. The settings for the voltage and angle are the commonly used values of 5% and 10 degrees respectively. It is evident, compared to the previous example using the absolute voltage method,

that the acceptance window is much wider. More importantly, the ES-25 relay allows for more flexibility. If a generator is equipped with a precise regulator, the voltage setting can be reduced without affecting the angle acceptance. Similarly, if the governor and engine controls are precise, the angle can be narrowed without affecting the voltage criterion. In Figure 3, the generator and bus voltages are 120 volts at 0 degrees and 115.9 volts at 2.1 degrees respectively. This easily allows the synchronization to take place without extending beyond the desired 5% voltage magnitude difference.

The independent voltage and angle settings of the ES-25 relay make it easy to follow the generator manufacturer's recommended allowable maximums for voltage and angle difference while synchronizing. This eliminates the need to compromise one synchronization criterion to achieve the other, making it easier to safely and quickly synchronize the generator to another system.

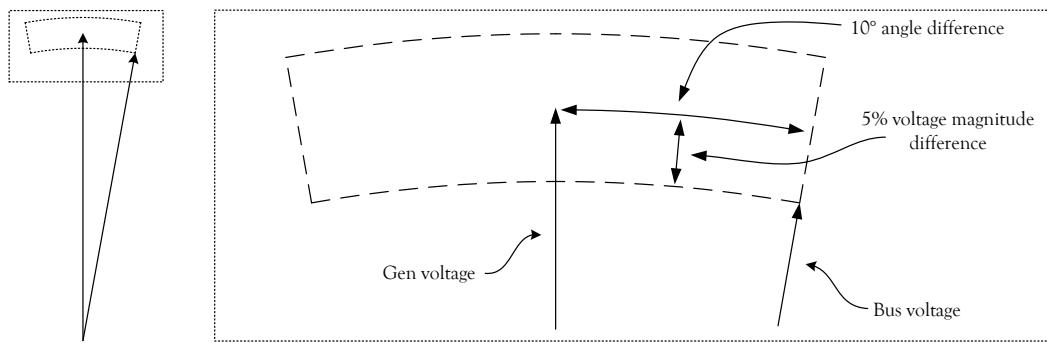


Figure 2 - Synchronization Acceptance Window Relative to Generator Voltage

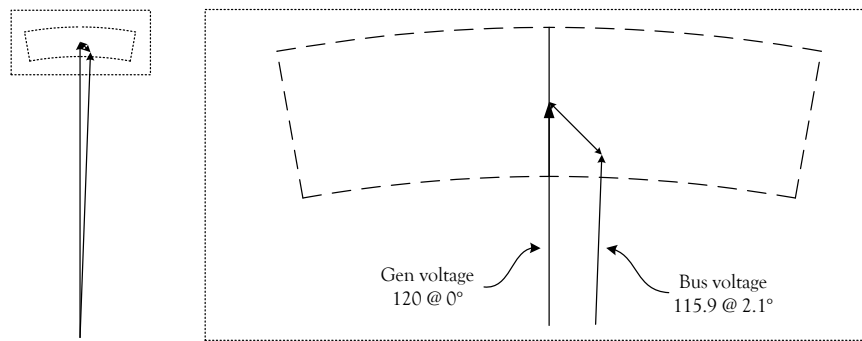


Figure 3 - Generator and Bus Voltages and Angles within Acceptable Synchronization Limits