Bus Configuration Report

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Overview of Bus Configuration

The bus configuration in a substation is the layout of conductors that connect the different pieces of electrical equipment. It connects the transformer(s), circuit breakers, disconnect switches, and other equipment all together. This determines the power flowing in, out, and throughout a substation. Different configurations offer different benefits, such as higher reliability or a smaller area. However, each also provides restrictions, such as high pricing or taking up a large amount of area. Six bus configurations are seen in substations; we researched all of them to decide which configuration would be best for our design. The different configurations are generally used at different voltage levels. Radial/Sectionalized and Main and Transfer configurations are typically used in low voltage generation sites, around 11kV to 66kV. Double Breaker Double Bus configuration is typically used in high voltage generation sites above 220kV. Breaker and a Half, as well as Ring Bus configurations, are both used for mid-voltage generation substations, which operate somewhere between 66kV and 220kV; however, ring bus is seen as the most commonly used for stations with this generation level.

Radial/Sectionalized Configuration

A radial configuration is a relatively straightforward bus configuration seen in substations. It is most commonly used in rural areas that do not require much reliability or high power levels. This configuration is simple by having one source feeding the load, but it gives little to no reliability. If a single fault occurred on the bus connecting the two lines, it would cause the entire substation to be inoperable due to no breaker on this line. A sectionalized configuration is an extension of the radial configuration. This configuration is comparable to having two radial configurations being sectionalized by a breaker. In our station, we seek a reliable configuration to manage multiple power sources, even in the event of a fault, alongside our power rating of 69kV/138kV, which is higher than the rating this system is typically used for. Due to the lack of reliability of these configurations and the higher power rating we have, we decided against using them.

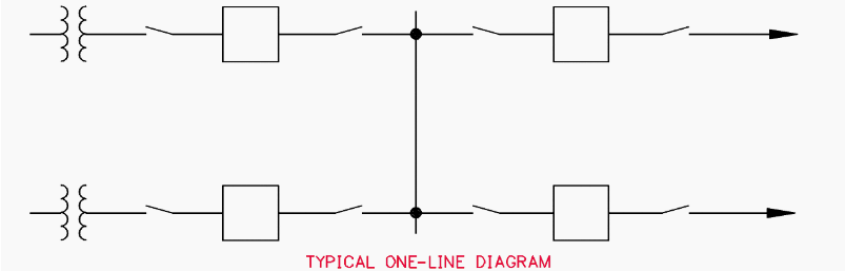

Figure 1: Radial Configuration

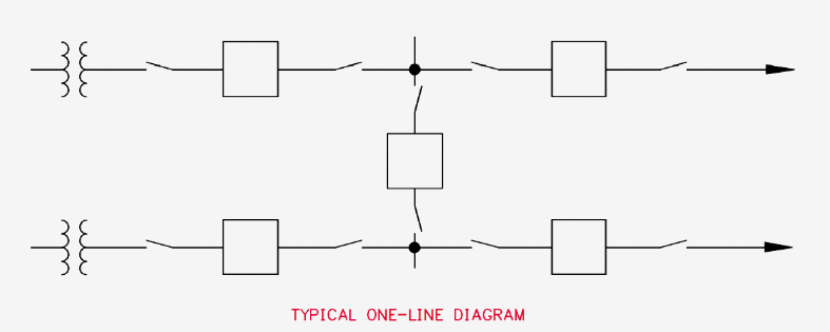

Figure 2: Sectionalized Bus Configuration

Main and Transfer Configuration

The main and transfer configuration has a single main bus that is energized with multiple independent lines tapping off. Various power sources could be done by having a separate main and transfer for all the lines; however, this would complicate connections. While this system is low-cost due to the limited number of breakers it requires, and easily expandable, it shares a similar flaw to the radial configuration in which it offers very low reliability. One fault on the main bus would de-energize each independent line, causing a total loss in power. Even though the other sources would remain untouched, maintenance would be challenging due to the complex switching needed to remove a circuit breaker for repairs.

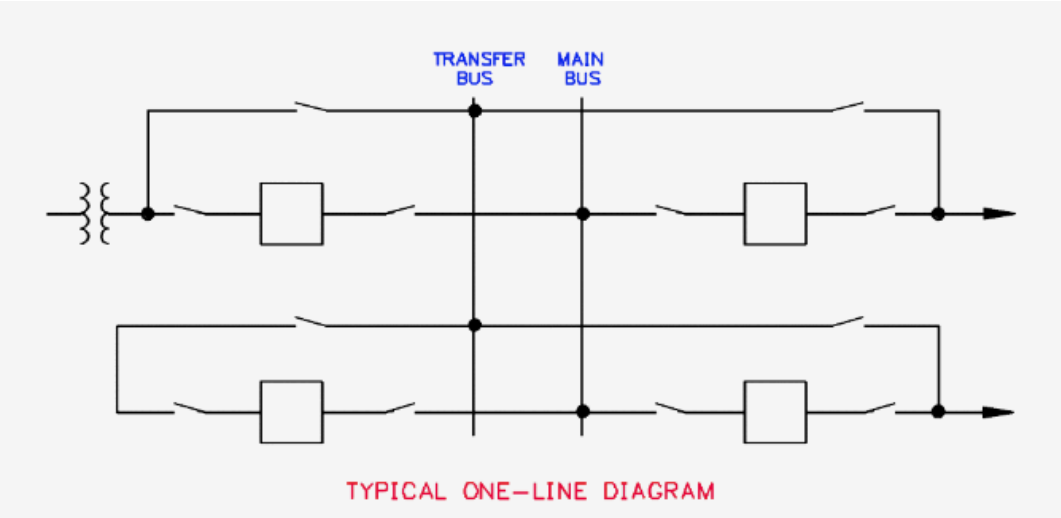

Figure 3: Main and Transfer Bus Configuration

Breaker and a Half Configuration

In this arrangement, two main buses are connected using three independent circuit breakers, this means that effectively each main bus has one and a half breakers associated with it. A benefit of breaker and a half is that if one line experiences a fault, the rest

remain energized and untouched, this level of reliability is what we are looking for in our site. An added benefit of a breaker and a half provides a way to achieve a double feed into every circuit. This is not needed at our site, but since this configuration is easily expandable, a double feed could be implemented in the future. This configuration would work for our case because it allows us to have a high level of reliability; however, we feel it adds unnecessary complexity due to the high number of breakers. The high number of breakers potentially could cause any maintenance or repairs to be complicated due to spacing concerns, and thus, we have decided against using this configuration for our site.

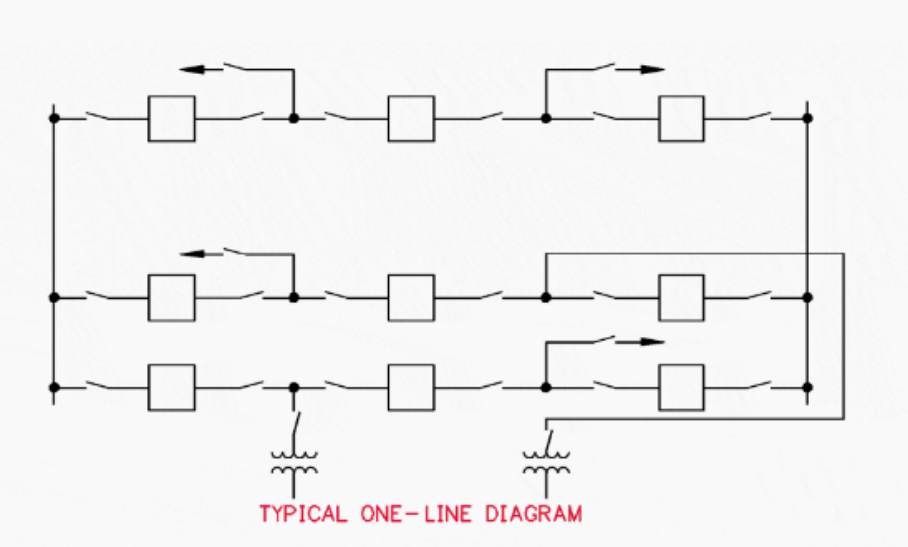

Figure 4: Breaker and a Half Bus Configuration

Double Breaker Double Bus Configuration

Double breaker double bus configuration is a scenario where every two main buses are connected through 2 circuit breakers, each with their own independent circuit. While this offers a very high level of reliability, our research showed that it was excessive for our project as this configuration is used in very high-generation sites (above 220kV). Due to the fact our site is not a high generation site, it is 138kV, we do not feel this configuration is suitable. In this case, all of the extra breakers cause the cost of this configuration to be very high, over double that of the sectionalized configuration. The high number of breakers would also make maintenance more complicated as breakers take up space and having an unnecessary amount could limit the amount of room maintenance vehicles would have. Ultimately, this configuration is not ideal for our site due to unnecessary reliability and maintenance challenges.

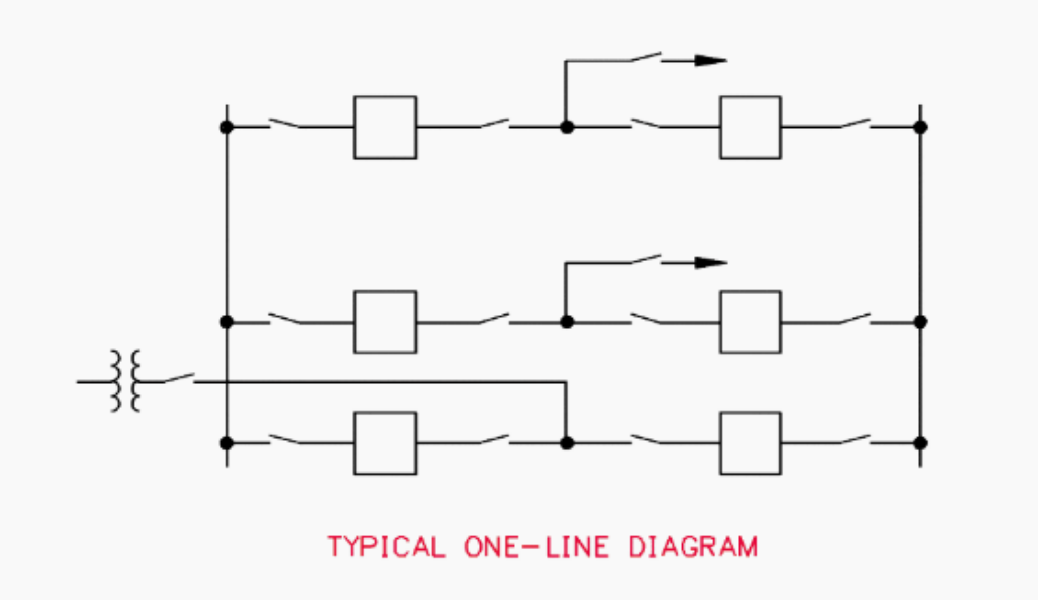

Figure 5: Double Breaker Double Bus Bus Configuration

Ring Bus Configuration

A ring bus configuration is one of the industry's most common bus configurations for mid-level generation, 66 kV - 220 kV, substations. They are reasonably simple to implement with a relatively low cost and somewhat high level of reliability. A ring bus connects two open ends of two main buses together through a breaker. This allows for a separate “section” of the bus for each input. In the event of a fault on one line, no other line would be affected, and the station could remain energized. This is the level of reliability we are looking for in our site. Unlike the breaker-and-a-half configuration that gives the same level of reliability, this configuration makes maintenance easy due to the simple switching of breakers to isolate a single line. An added benefit to this configuration is in the event of expansion, the site would not have to be de-energized due to breakers located on each side of the lines. Overall, this configuration gives us the level of reliability we are looking for, without introducing a high level of complexity in the piloting scheme and breaker switching for maintenance. For these reasons we have decided to use this configuration in our project.

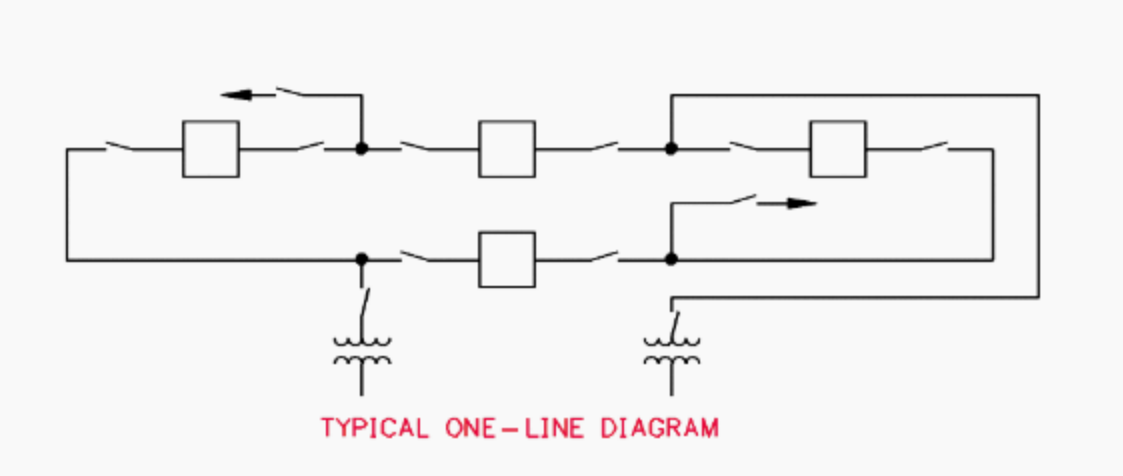

Figure 6: Ring Bus Configuration

Conclusion

We decided to use a ring bus configuration for our specific substation. While we believe a breaker-and-a-half would also work in our station, the ring bus configuration gives us the same level of reliability without adding any unnecessary complexity of a higher number of breakers since our station is not a high-generation station. The ring bus configuration is also easily expandable due to the simple layout of the breakers and input lines. The ring bus allows for the level of reliability you would expect and desire in a station of this voltage while keeping the design of the bus configuration simple when compared to other configurations.

References

Figures 1-6:

EEP - Electrical Engineering Portal, and Edvard Csanyi. “Six Common Bus Configurations in Substations up to 345 Kv: EEP.” *EEP - Electrical Engineering Portal*, 12 Aug. 2022, electrical-engineering-portal.com/bus-configurations-substations-345-kv.