



Exelon Utilities Transmission Bus Configuration Design Philosophy

Rev 1

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The intent of this document is to provide bus configuration guidelines for new substations interconnected to the transmission systems across the Exelon Utilities (EU) companies. These guidelines should also be taken into consideration when major substation modifications take place. The guidelines presented in this document are consistent with PJM's Transmission Owner Technical Guidelines & Recommendations for Substation Bus Configuration Requirements, PJM's Protection Standards, and other applicable Industry Standards. They are intended to preserve Exelon Utility transmission network reliability when Exelon itself, an Independent Power Producer, or a transmission customer/merchant interconnect to the transmission system. The guidelines are developed in such a way that a good balance between operational flexibility and economic feasibility is reached at each voltage level and configuration.

Bus Configuration Types and Exelon Requirements

Breaker-and-a-Half

The breaker-and-a-half configuration is composed of two main buses connected by element strings (bays).

- Each element string is composed of circuit breakers, transformers or line elements as shown in Figure 1.
- When multiple element strings are installed then it is acceptable to initially have three element strings attached to the same bus section, but when the 4th element string is added then bus-sectionalizing breakers should be installed such that no more than two element strings are grouped on the same bus section.
- Note that all elements in a breaker-and-a-half scheme terminate between breakers with no elements connected directly to the main buses. The only exception is for a shunt inductor or capacitor bank that are required to be connected through a circuit breaker.
- Each element is connected to the element string with a minimum of a disconnect switch.
 - This would ensure that the element string(s) remains intact while one or more of the elements connected to the element string(s) is taken out of service for an extended period of time for scheduled maintenance or repairs.
- Stuck breaker scenarios will not result in the loss of more than 300 MVA (when load is being served) and should be evaluated for reliability and operational impacts.
- Extended maintenance outages of any of the elements should be evaluated for reliability and operational impacts.

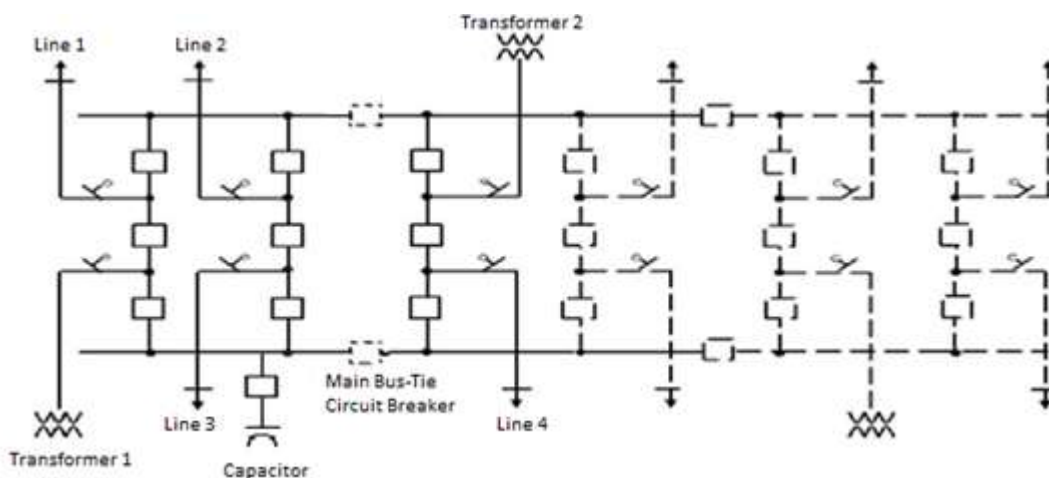


Figure 1. Breaker-and-a-Half configuration

Ring Bus

The ring bus configuration is composed of several bus sections connected through bus-tie circuit breakers as shown in Figure 2.

- One element is connected to each dedicated bus section; therefore, the isolation of any one element requires the operation of two bus-tie circuit breakers.
- Each element is connected to the bus via a minimum of a disconnect switch, except for shunt devices (inductor or capacitor) which require a breaker.
 - This would ensure that the bus remains intact while one or more of the elements connected to the bus is taken out of service for an extended period of time for scheduled maintenance or repairs.
- Source and sink elements are alternated around the ring if possible
- Elements of a common type or to the same remote substation are not adjacent to one another.
- Per Table 1 below, ring buses may need to be designed such that future expansion to accommodate conversion to a breaker-and-a-half configuration is possible.
- At existing nuclear stations that use a ring bus design, any new or significantly modified line connections should use a line circuit breaker, if practical, to prevent opening the nuclear station ring bus for line events or maintenance activities.
- Stuck breaker scenarios will not result in the loss of more than 300 MVA (when load is being served) and should be evaluated for reliability and operational impacts.
- Extended maintenance outages of any of the elements should be evaluated for reliability and operational impacts.
- If two rings are connected through one breaker the tie breaker should be protected from system faults when possible.

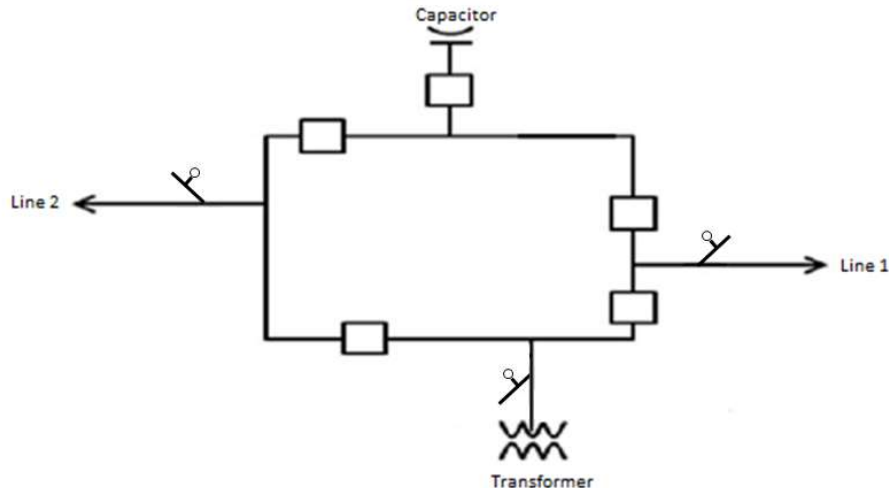


Figure 2. Ring Bus

Straight Bus

The straight bus configuration is composed of a limited number of bus sections in which transmission elements terminate at a bus section through a circuit breaker as shown in Figure 3.

- No more than three bus sections (two bus sections per color on the ComEd transmission system) are allowed at any one substation
- No more than three elements are connected on each bus section
- In each bus section, source/sink points are evenly split if possible.

- Each bus section is separated by a double bus tie breaker so as not to take out two buses in a breaker failure scenario
- Each element is connected to the bus via a circuit breaker.
- Stuck breaker scenarios will not result in the loss of more than 300 MVA (when load is being served) and should be evaluated for reliability and operational impacts.
- Extended maintenance outages of any of the elements should be evaluated for reliability and operational impacts.

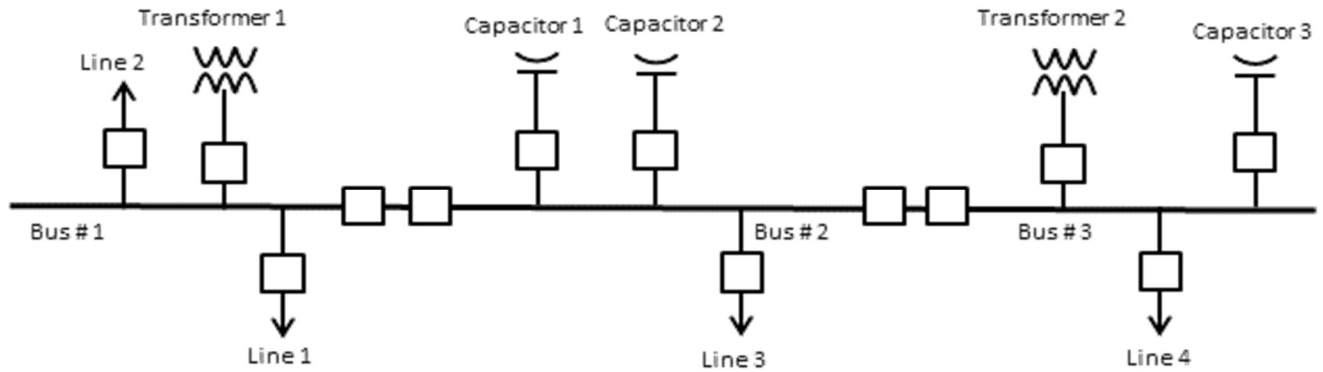


Figure 3. Straight Bus

Exelon Transmission Substation Bus Configuration Guideline

Voltage / Scenario	Breaker and 1/2	Ring	Straight
765kV, 500kV, or 345kV	Required for >= 5 elements	Allowed for <= 4 elements	⊗
230kV, 138kV, 115kV, 69kV	✓ Preferred	Allowed for <= 7 elements	Only in very limited situations (not allowed for 230kV)

Table 1

Notes:

- In all cases studies must be performed to confirm acceptability of design. These studies should include stuck breaker and maintenance outage scenarios.
- The requirements in the description section must be recognized for each case.
- There may be exceptions which will need to be evaluated and approved on a case by case basis. These exceptions could be driven by issues such as lack of real estate or other issues.
- For Exelon West - ComEd, the design should maintain the split bus concept used throughout the system where normally open tie(s) exist between sides where appropriate to limit fault current and improve operability.