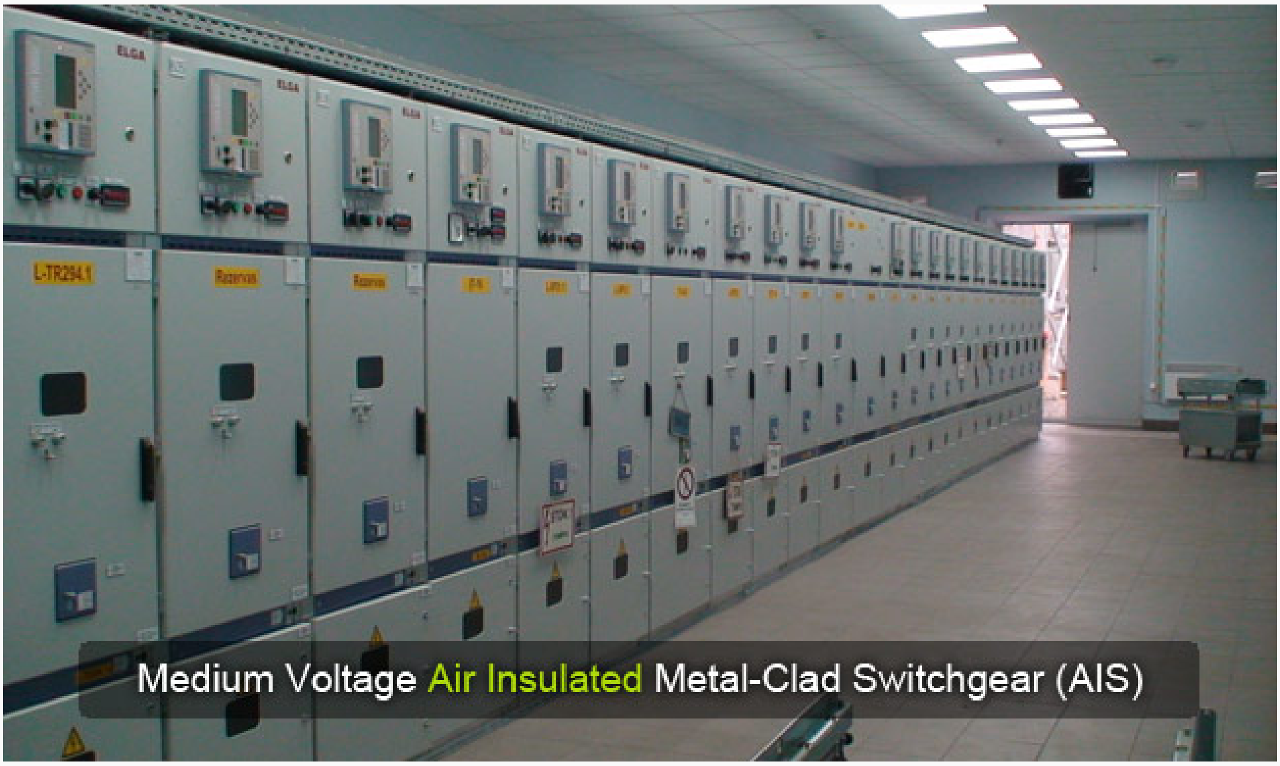
Bus Switching Configurations In Air Insulated Substations (AIS)

Edvard



Medium Voltage Air Insulated Metal-Clad Switchgear (AIS)

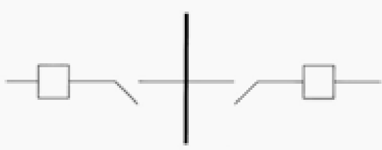
Various factors affect the reliability of a substation, one of which is the arrangement of the switching devices. Arrangement of the switching devices will impact maintenance, protection, initial substation development, and cost.

There are six types of substation bus switching arrangements commonly used in air insulated substations:

1. Single bus
2. Double bus, double breaker
3. Main and transfer (inspection) bus
4. Double bus, single breaker
5. Ring bus
6. Breaker and a half

1. Single Bus Configuration

This arrangement involves one main bus with all circuits connected directly to the bus. The reliability of this type of an arrangement is very low. When properly protected by relaying, a single failure to the main bus or any circuit section between its circuit breaker and the main bus will cause an outage of the entire system. In addition, maintenance of devices on this system requires the de-energizing of the line connected to the device.



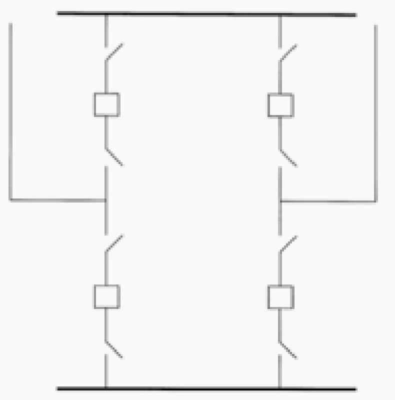
Single bus configuration

Maintenance of the bus would require the outage of the total system, use of standby generation, or switching to adjacent station, if available. Since the single bus arrangement is low in reliability, it is not recommended for heavily loaded substations or substations having a high availability requirement.

Reliability of this arrangement can be improved by the addition of a bus tiebreaker to minimize the effect of a main bus failure.

2. Double Bus, Double Breaker Configuration

This scheme provides a very high level of reliability by having two separate breakers available to each circuit. In addition, with two separate buses, failure of a single bus will not impact either line. Maintenance of a bus or a circuit breaker in this arrangement can be accomplished without interrupting either of the circuits.

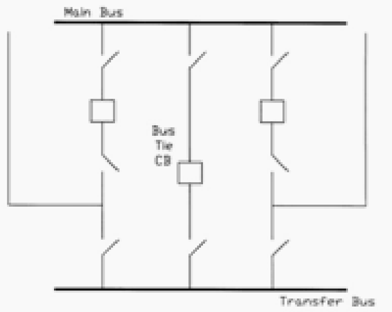


Double Bus, Double Breaker Configuration

This arrangement allows various operating options as additional lines are added to the arrangement; loading on the system can be shifted by connecting lines to only one bus. A double bus, double breaker scheme is a high-cost arrangement, since each line has two breakers and requires a larger area for the substation to accommodate the additional equipment. This is especially true in a low profile configuration.

The protection scheme is also more involved than a single bus scheme.

3. Main and Transfer Bus Configuration



Main and Transfer Bus Configuration

This scheme is arranged with all circuits connected between a main (operating) bus and a transfer bus (also referred to as an inspection bus). Some arrangements include a bus tie breaker that is connected between both buses with no circuits connected to it.

Since all circuits are connected to the single, main bus, reliability of this system is not very high. However, with the transfer bus available during maintenance, de-energizing of the circuit can be avoided. Some systems are operated with the transfer bus normally de-energized. When maintenance work is necessary, the transfer bus is energized by either closing the tie breaker, or when a tie breaker is not installed, closing the switches connected to the transfer bus. With these switches closed, the breaker to be maintained can be opened along with its isolation switches. Then the breaker is taken out of service. The circuit breaker remaining in service will now be connected to both circuits through the transfer bus.

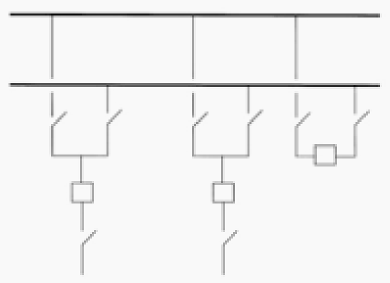
This way, both circuits remain energized during maintenance. Since each circuit may have a different circuit configuration, special relay settings may be used when operating in this abnormal arrangement.

When a bus tie breaker is present, the bus tie breaker is the breaker used to replace the breaker being maintained, and the other breaker is not connected to the transfer bus. A shortcoming of this scheme is that if the main bus is taken out of service, even though the circuits can remain energized through the transfer bus and its associated switches, there would be no relay protection for the circuits. Depending on the system arrangement, this concern can be minimized through the use of circuit protection devices (reclosure or fuses) on the lines outside the substation.

This arrangement is slightly more expensive than the single bus arrangement, but does provide more flexibility during maintenance. Protection of this scheme is similar to that of the single bus arrangement. The area required for a low profile substation with a main and transfer bus scheme is also greater than that of the single bus, due to the additional switches and bus.

4. Double Bus, Single Breaker Configuration

This scheme has two main buses connected to each line circuit breaker and a bus tie breaker. Utilizing the bus tie breaker in the closed position allows the transfer of line circuits from bus to bus by means of the switches. This arrangement allows the operation of the circuits from either bus. In this arrangement, a failure on one bus will not affect the other bus.



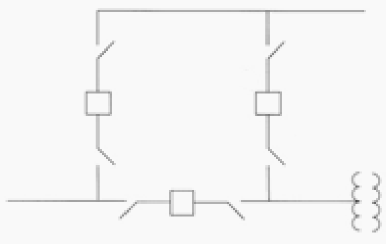
Double Bus, Single Breaker Configuration

However, a bus tie breaker failure will cause the outage of the entire system. Operating the bus tie breaker in the normally open position defeats the advantages of the two main buses. It arranges the system into two single bus systems, which as described previously, has very low reliability. Relay protection for this scheme can be complex, depending on the system requirements, flexibility, and needs.

With two buses and a bus tie available, there is some ease in doing maintenance, but maintenance on line breakers and switches would still require outside the substation switching to avoid outages.

5. Ring Bus Configuration

In this scheme, as indicated by the name, all breakers are arranged in a ring with circuits tapped between breakers. For a failure on a circuit, the two adjacent breakers will trip without affecting the rest of the system. Similarly, a single bus failure will only affect the adjacent breakers and allow the rest of the system to remain energized. However, a breaker failure or breakers that fail to trip will require adjacent breakers to be tripped to isolate the fault.



Ring Bus Configuration

Maintenance on a circuit breaker in this scheme can be accomplished without interrupting any circuit, including the two circuits adjacent to the breaker being maintained. The breaker to be maintained is taken out of service by tripping the breaker, then opening its isolation switches. Since the other breakers adjacent to the breaker being maintained are in service, they will continue to supply the circuits. In order to gain the highest reliability with a ring bus scheme, load and source circuits should be alternated when connecting to the scheme.

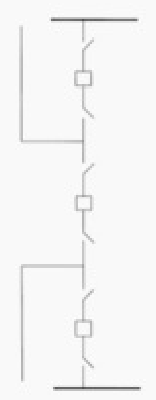
Arranging the scheme in this manner will minimize the potential for the loss of the supply to the ring bus due to a breaker failure. Relaying is more complex in this scheme than some previously identified. Since there is only one bus in this scheme, the area required to develop this scheme is less than some of the previously discussed schemes. However, expansion of a ring bus is limited, due to the practical arrangement of circuits.

6. Breaker-and-a-Half Configuration

The breaker-and-a-half scheme can be developed from a ring bus arrangement as the number of circuits increases. In this scheme, each circuit is between two circuit breakers, and there are two main buses. The failure of a circuit will trip the two adjacent breakers and not interrupt any other circuit. With the three breaker arrangement for each bay, a center breaker failure will cause the loss of the two adjacent circuits. However, a breaker failure of the breaker adjacent to the bus will only interrupt one circuit.

Maintenance of a breaker on this scheme can be performed without an outage to any circuit. Further- more, either bus can be taken out of service with no interruption to the service. This is one of the most reliable arrangements, and it can continue to be expanded as required. Relaying is more involved than some schemes previously discussed.

This scheme will require more area and is costly due to the additional components.



Breaker-and-a-Half Configuration

Comparison table of configurations:

Configuration	Reliability	Cost	Available area
.Single bus	Least reliable — single failure can cause complete outage	Least cost — fewer components	Least area — fewer components
.Double bus	Highly reliable — duplicated components; single failure normally isolates single component	High cost — duplicated components	Greater area — twice as many components
.Main bus and .transfer	Least reliable — same as Single bus, but flexibility in operating and maintenance with transfer bus	Moderate cost — fewer components	Low area requirement — fewer components
.Double bus, .single breaker	Moderately reliable — depends on arrangement of components and bus	Moderate cost — more components	Moderate area — more components
.Ring bus	High reliability — single failure isolates single component	Moderate cost — more components	Moderate area — increases with number of circuits
.Breaker and a.half	Highly reliable — single circuit failure isolates single circuit, bus failures do not affect circuits	Moderate cost — breaker-and-a-half for each circuit	Greater area — more components per circuit

Resource: CsanyiGroup – Air Insulated Substations – Bus/Switching Configurations

Source: http://electrical-engineering-portal.com/bus-switching-configurations-in-air-insulated-substations-ais