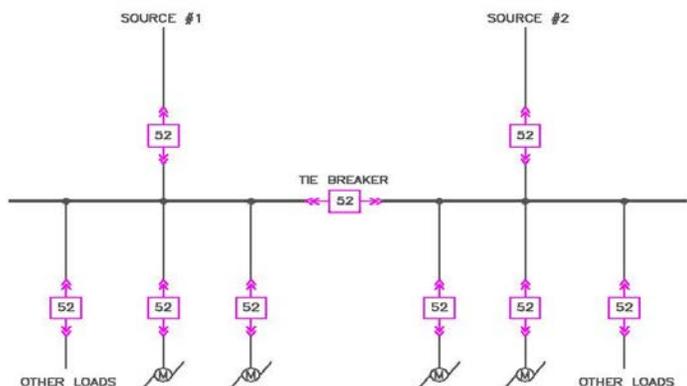


## Secondary Selective Power Distribution Automatic Transfer

### Introduction

When designing electrical power distribution system, designer can choose from many configurations available at his or her disposal to maximize many variables including reliability, efficiency, economics, simplicity of operation, etc. Secondary selective system configuration, which consists of Main – Tie – Main (MTM) circuit breakers, is shown below.



This configuration provides enhanced load recovery following faults or outage and provides operational flexibility. Maintenance of upstream transformer, cable, and switchgear bus doesn't require a shutdown since affected main can be taken out of service while other main and tie breaker maintain continuity of power to all the loads.

### Open Versus Closed Tie

Designing secondary selective systems, designer will need to choose between a closed tie and open tie operation. With closed tie systems, there is no dead zone in case of failure of one of the source. However, fault duty of switchgear is doubled in closed tie configurations, increasing exposure risk to the technicians operating in the substation. Both closed-tie or open-tie system would require complete shutdown in case of tie breaker failure or bus fault with single ended operation.

### Bus Transfer – Open Tie Systems

In open tie configuration, bus transfer between the sources is challenging since fault duty increases substantially if momentary closure of all three breakers are allowed. In addition, motor's unique voltage decay and phase angle complicates bus transfer as seen in the equation below:

$$\%Torque = V^2 \frac{R \frac{r}{S}}{((Xs + Xr)^2 + (Rs + Rr/s)^2)^{1/2}}$$

We can surmise from the equation above that torque is proportional to the square of the voltage. As a result, reenergizing a bus full of motors too quickly or at the wrong time may cause shearing of shafts, causing a major disaster. ANSI standard C50.41 specifies reclosure limit of 1.33 per unit (pu) volts per hertz from the motor rated voltage and frequency bases. Therefore, electrical voltage and resulting torque should not exceed 1.33 pu or 1.77 pu respectively.

### Bus Transfer Schemes – Open Tie Systems

The loss of a source triggers initiation of transfer of power to the remaining source by closing the tie breaker. To meet above mentioned reclosure criteria, there are typically four bus transfer schemes available as outlined below:

- Slow transfer scheme: Bus transfer is allowed only after predetermined safe period of time. Advantages include reduce cost and complexities. Disadvantages include complete loss of power and potential motor damage if timing is miscalculated.
- Residual transfer scheme: Bus transfer is allowed only after decaying bus voltage drops to a predetermined level. Advantages include reduce cost and complexities. Disadvantages include momentary paralleling of sources when returning to normal operation and possible load shedding requirement.
- In-phase transfer scheme: Bus transfer is allowed when decaying bus phase angle is predicted to be in phase with the healthy source. Advantage includes continuous operation. Disadvantages include possible damage to motors and the load shedding requirement.
- Fast transfer scheme: Bus transfer is allowed as soon as possible, possibly within one or two cycles. Advantage includes continuous operation. Disadvantages include possible damage to motors and the load shedding requirement.

### Conclusion

Each of these schemes has its sets of advantages and disadvantages. Designer must evaluate continuity of service, safety, reliability, economics, etc. in selecting the appropriate bus transfer scheme for a facility. In addition, designer must select between discrete devices or Programmable Logic Controller (PLC) to perform automatic transfer function.