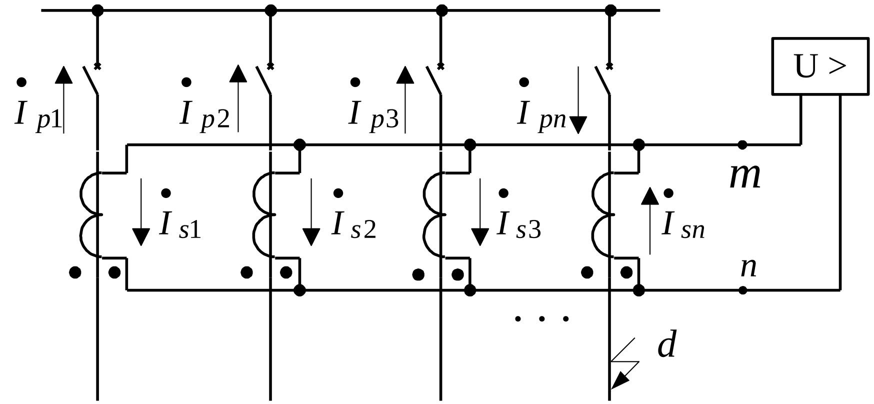
EEE340 Protective Relaying

Lecture 20 – Bus Protection 2

High Impedance Bus Differential Protection

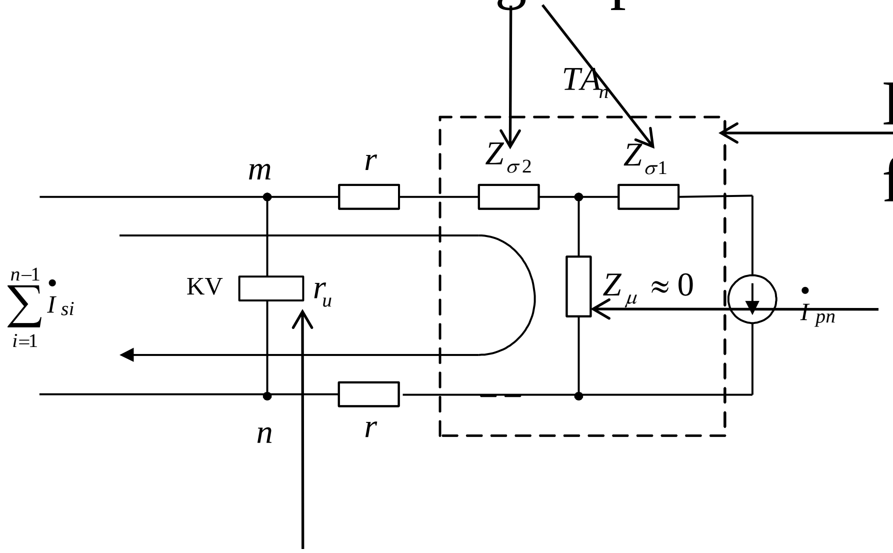
In case of external faults, for complete differential protection, if the current of the faulted branch is very large and the currents of non-faulted branches may not be large;

The TA of the faulted branch then may be saturated with very small secondary current and TAs of non-faulted branches may not be saturated, so the differential current may be large to trip the protection;



High Impedance Bus Differential Protection

Winding impedance



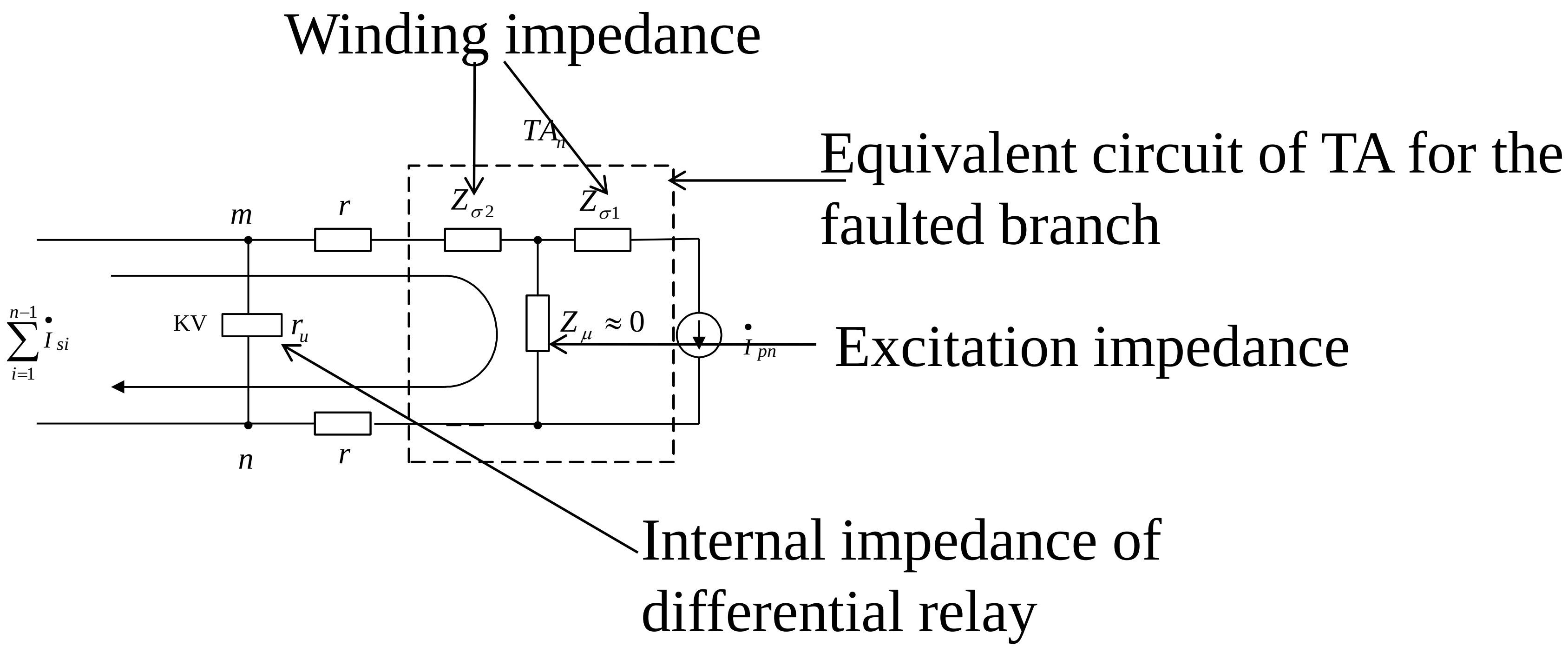
Equivalent circuit of TA for the faulted branch

Excitation impedance

Internal impedance of differential relay

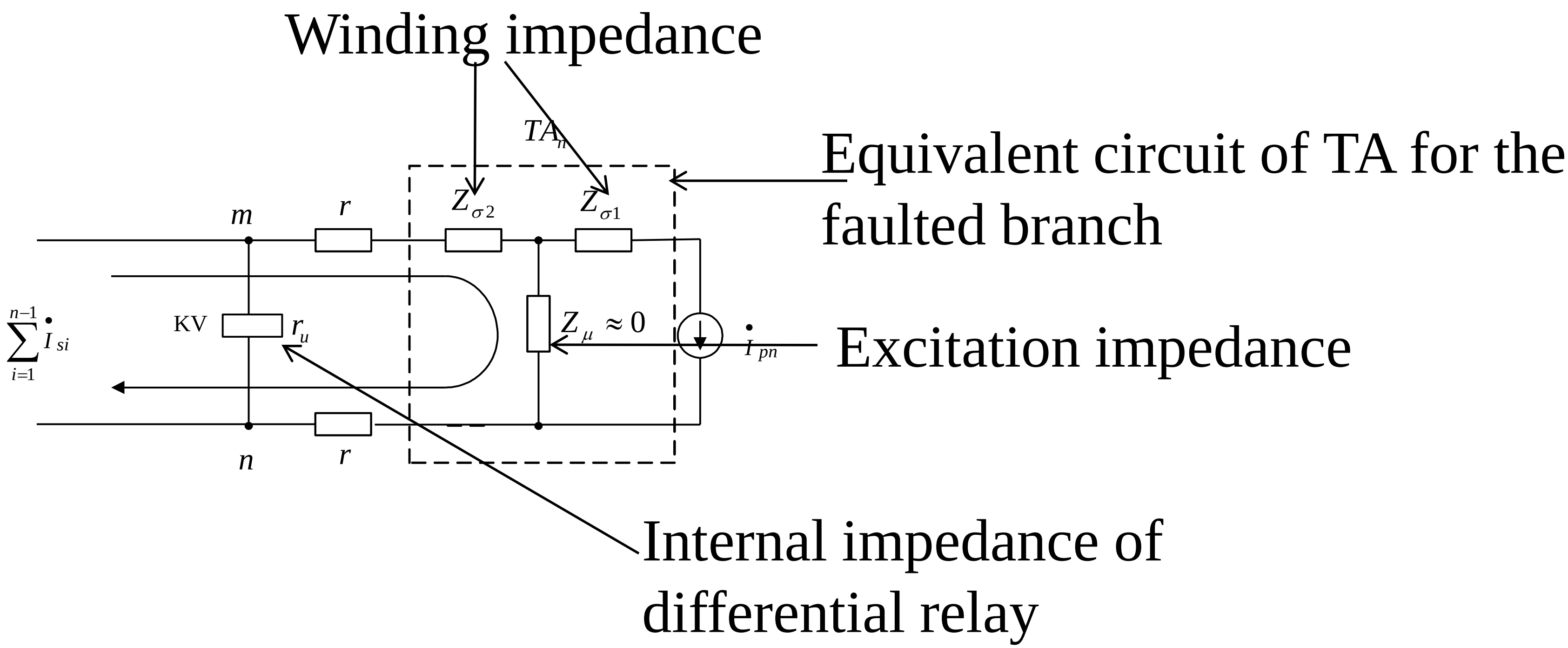
In case of external faults and if all TAs have no errors, the sum of secondary currents for non-faulted branches is equal to the secondary current of the faulted branch with opposite direction; no current flow through the differential relay.

High Impedance Bus Differential Protection



If the TA of the faulted branch is highly saturated, most primary current may flow through the excitation branch as the excitation impedance would be very small; as the internal impedance of differential relay is very high, the secondary currents of non-faulted branches will flow through the secondary winding of the TA of the faulted branch. The differential relay will not operate.

High Impedance Bus Differential Protection



In case of internal faults, the currents of all branches flow into the bus, so all secondary currents will flow into the voltage relay; because its internal impedance is high, so the terminal voltage will be high enough to trip the protection.

Medium Impedance Bus Protection with Percentage Restraint

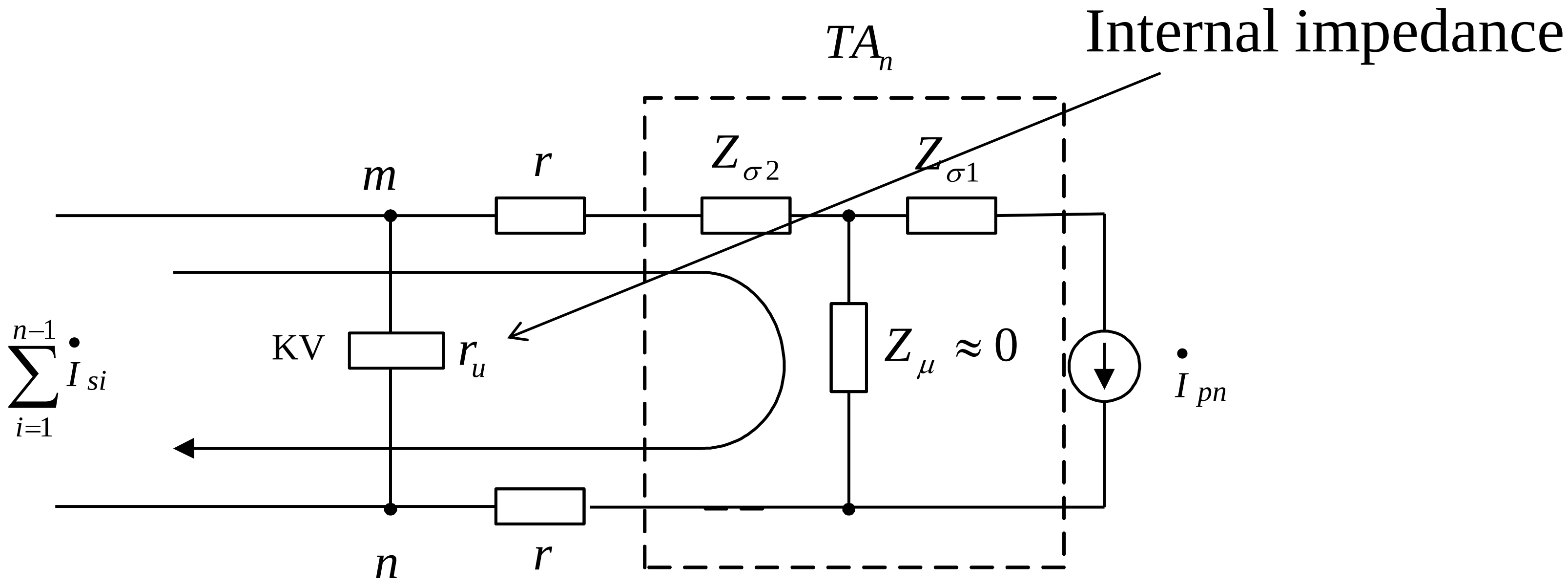
$$\left|\sum_{i=1}^{n}\dot{I}_i\right| - K_{res}\left\{\left|\dot{I}_i\right|\right\}_{\max} \geq I_{set.0}, \qquad \text{i=1,2,3,...,n}$$

or

$$\left|\sum_{i=1}^{n}\dot{I}_i\right| - K_{res}\sum_{i=1}^{n}\left|\dot{I}_i\right| \geq I_{set.0}, \qquad \text{i=1,2,3,...,n}$$

If the TA of the faulted branch is highly saturated in case of external faults, the secondary current of this TA may be close to zero; then the largest restraint current is lost, and the protection may be falsely tripped.

Medium Impedance Bus Protection with Percentage Restraint



The internal impedance can be increased in the differential circuit, then the currents of other branches will flow through the TA secondary side of the faulted branch also as restraint current. The impedance of differential circuit is not as high as high impedance differential protection, so it is called as medium impedance differential protection.

Phase Current Comparison Bus Protection

Because of the unbalance current, the sensitivity of normal differential protection may be impacted.

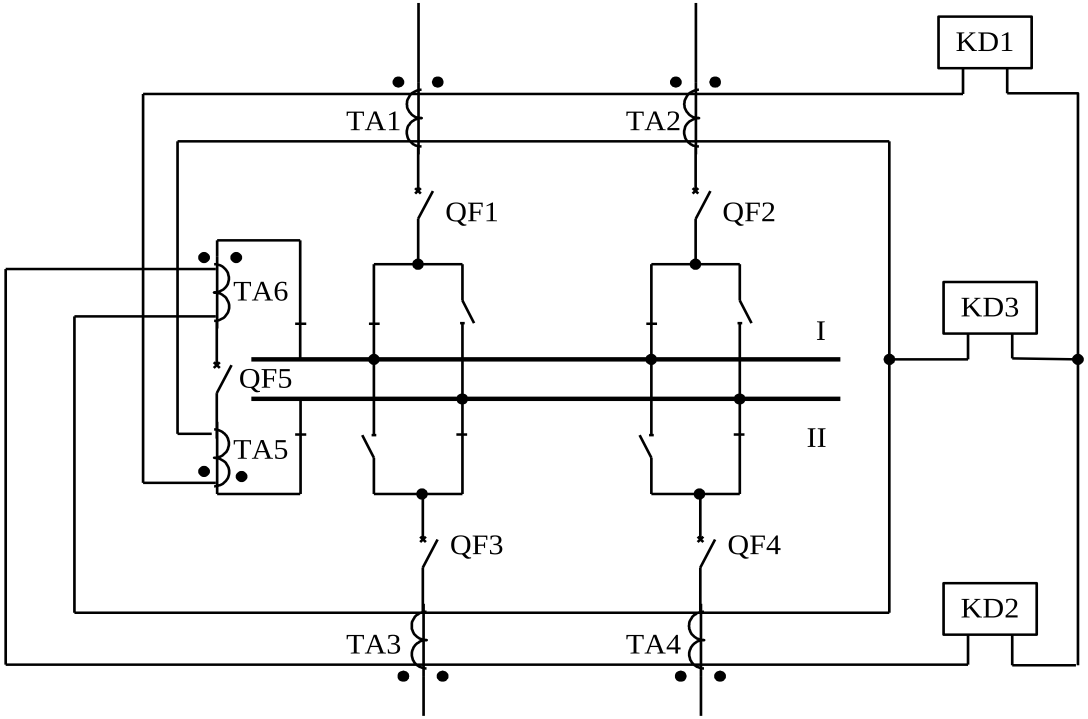
The different relation among phase angles of branches during normal operation or external faults and internal faults can be applied to construct another type of protection.

In case of internal faults, the phase angles of all source branches are almost the same;

Incase of external faults, the current of non-faulted source branch would flow into the bus, and the current of the faulted branch would flow out of the bus with opposite phase angles.

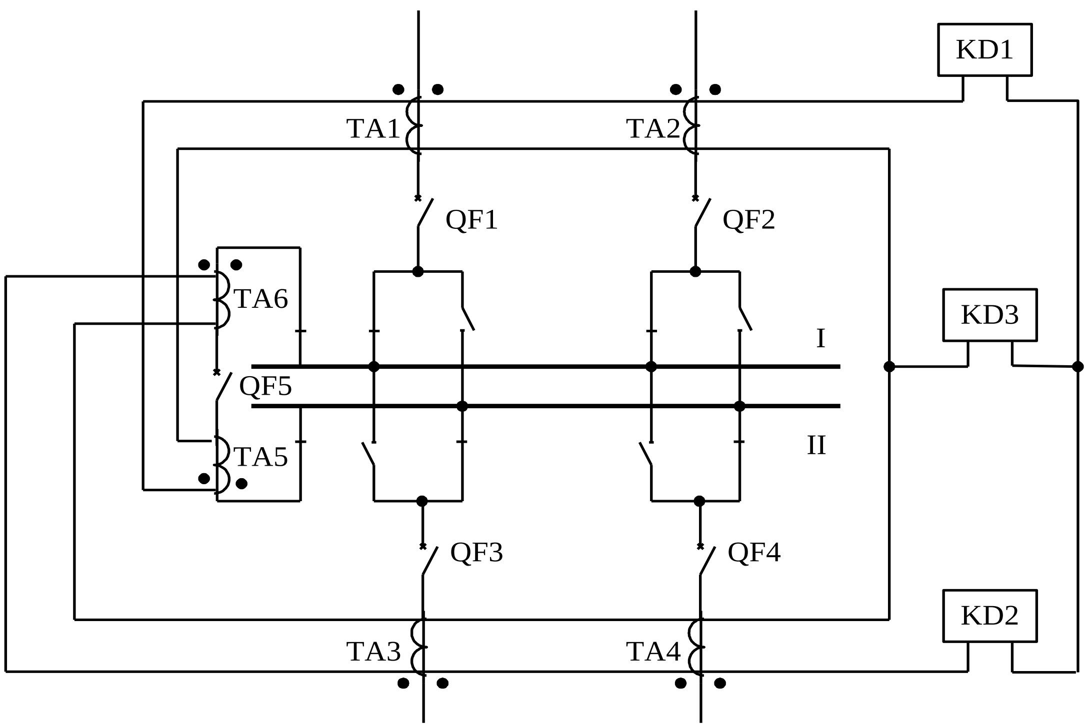
Differential Protection for Permanent Connected Double Busbar Systems

For double bus systems, if the connections of branches or components to each bus are permanent and fixed, this protection can be applied.
But if the connection is permanent, that may reduce the flexibility of system operation.



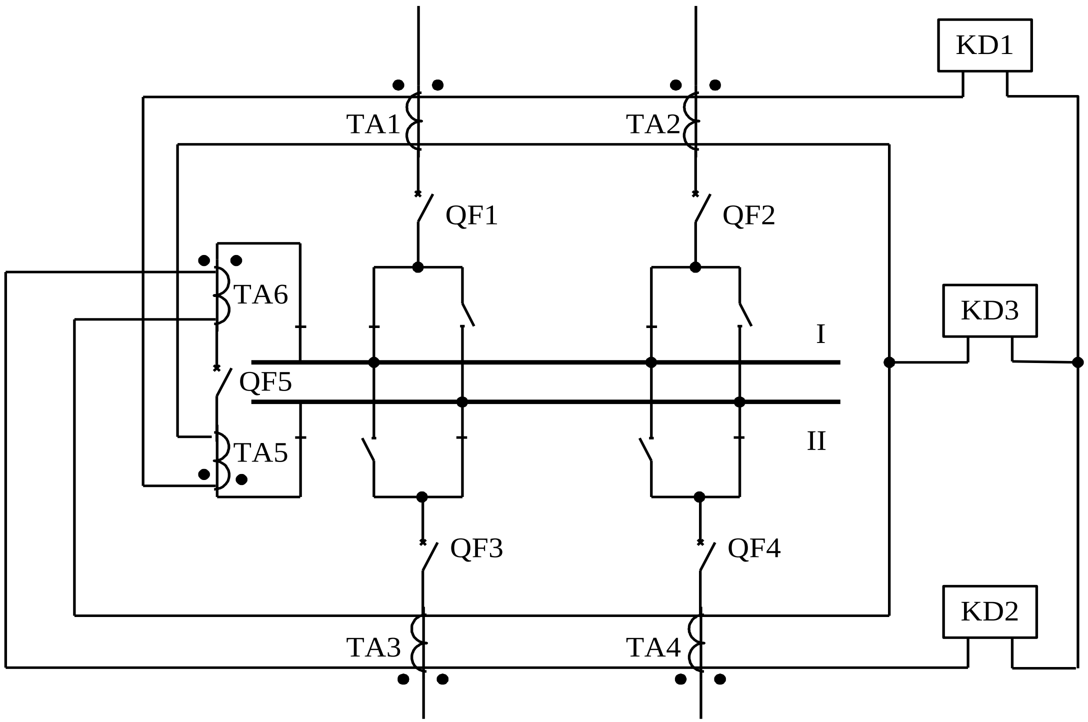
Differential Protection for Permanent Connected Double Bus Systems

There are three sets of differential protections totally;
Set 1: TA1, TA2, TA5 and differential relay KD1, for faults of bus I;
Set 2: TA3, TA4, TA6 and differential relay KD2, for faults of bus II;
Set 3: TA1, TA2, TA3, TA4 and differential relay KD3 for faults of both buses.



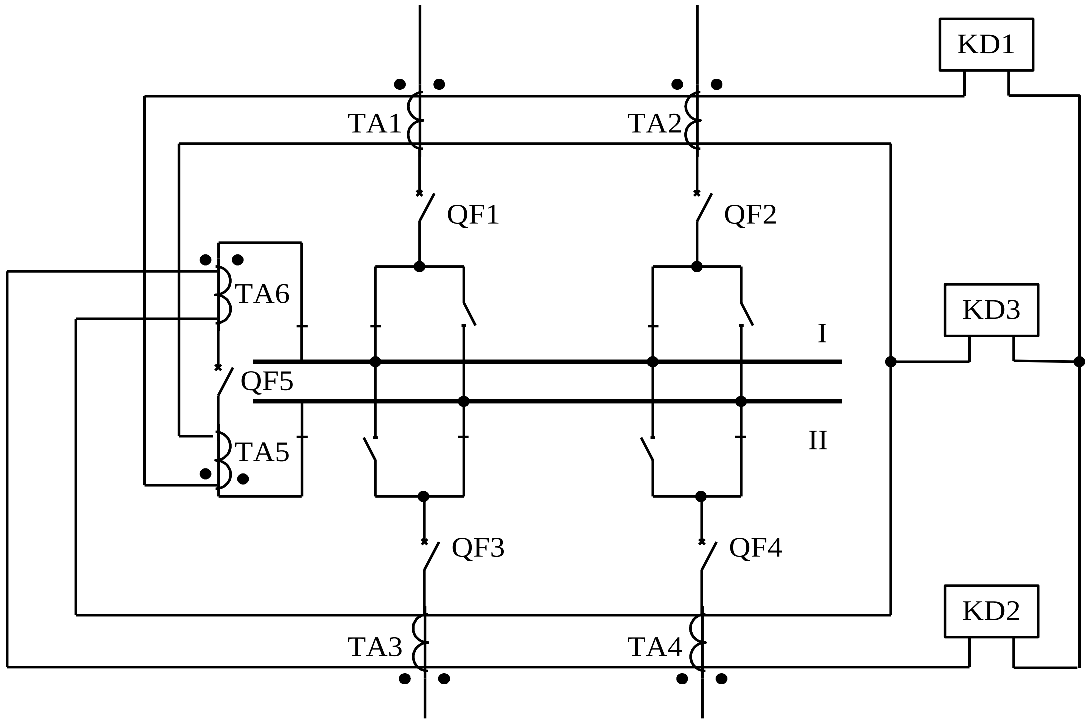
Differential Protection for Permanent Connected Double Bus Systems

In case of fault on bus I, The fault current will flow through KD1 and KD3, but the current through KD2 is the unbalance current; so KD1 and KD3 will be activated; KD3 will trip QF5 and KD1 will trip QF1 and QF2. Bus I is disconnected and Bus II can continue to operate.

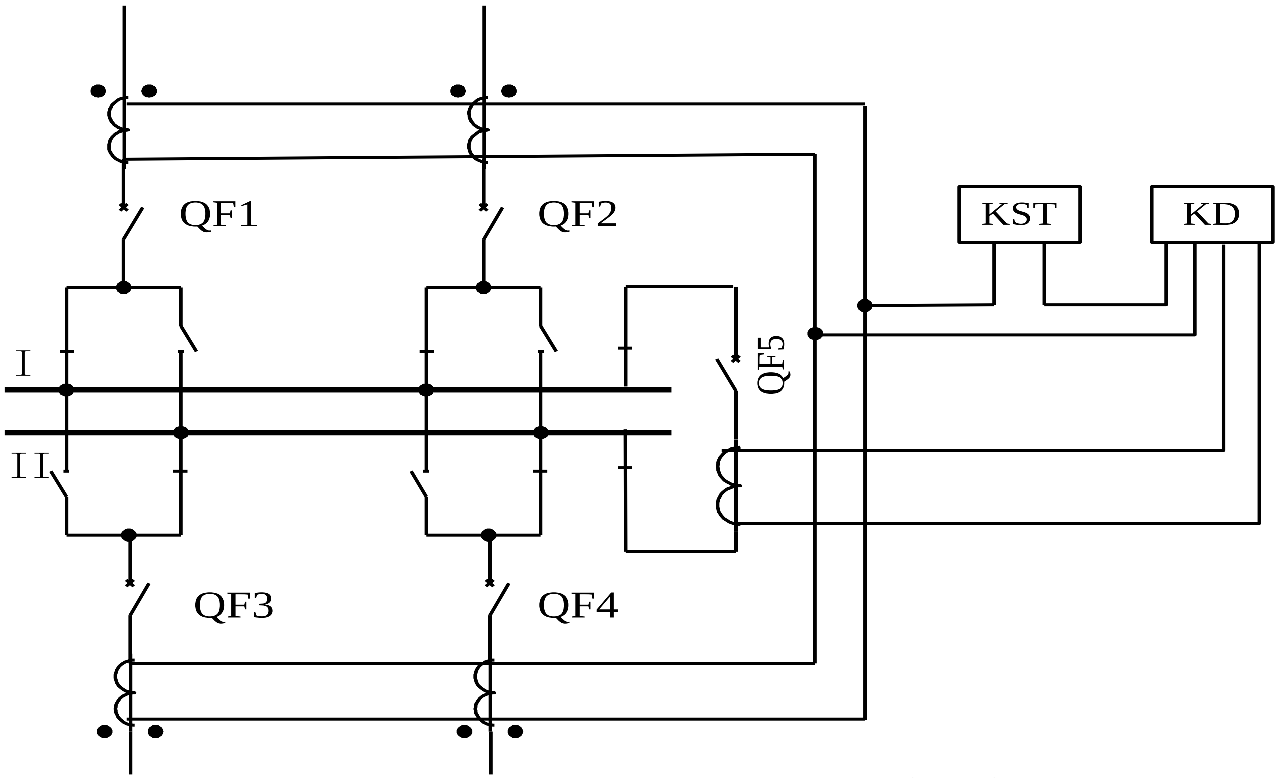


Differential Protection for Permanent Connected Double Bus Systems

If the connections of branches to both buses are changed, the protections for Bus I and II cannot distinguish the position of fault, both buses will be disconnected, selectivity will be lost.



Phase Comparison of Currents in the Interconnections between Buses



KST is the starting component and KD is the phase comparison component.

To keep selectivity even the connections to buses are changed.

KST judges if a fault happens on any of the buses; KD judges the position of fault according to the current phase through the interconnection (from I to II, or from II to I).

Breaker Failure Protection

In case of faults, although the protections can operate to trip the breakers, the breakers may fail to operate due to some faults of broken lines or mechanical operations.

A timing relay is activated when the protection operate to trip its corresponding breaker; after preset time, if the fault is not cleared, the timing relay will trip all other connected breakers in source branches to clear the fault.

Next Lecture

Thanks for your attendance