Solid-State Fault Current Limiting for DC Distribution Protection

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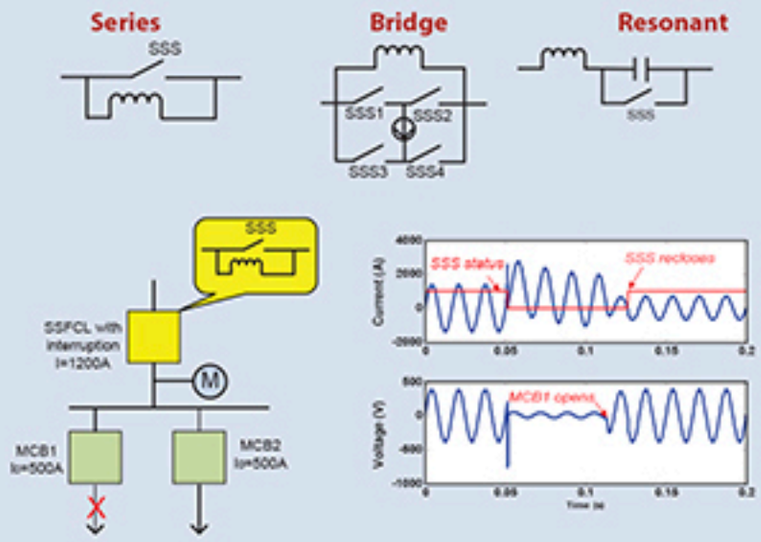
Solid state fault current limiters (SSFCL)

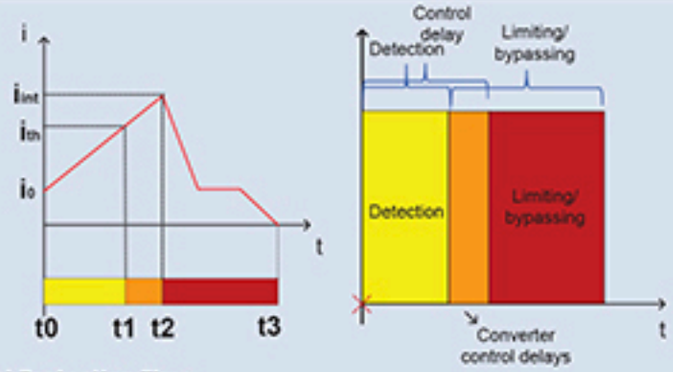
- SSFCL limit the fault current; Downstream MCB opens;
- Demonstration in an AC distribution network, similar implementation and results in DC distribution



Converter fault current limiting or bypassing

Hardware Requirements

- Active switches on fault paths;
- Active switching;
- DC disconnectors;
- Fault current tolerance of the converter;



Total Protection Time

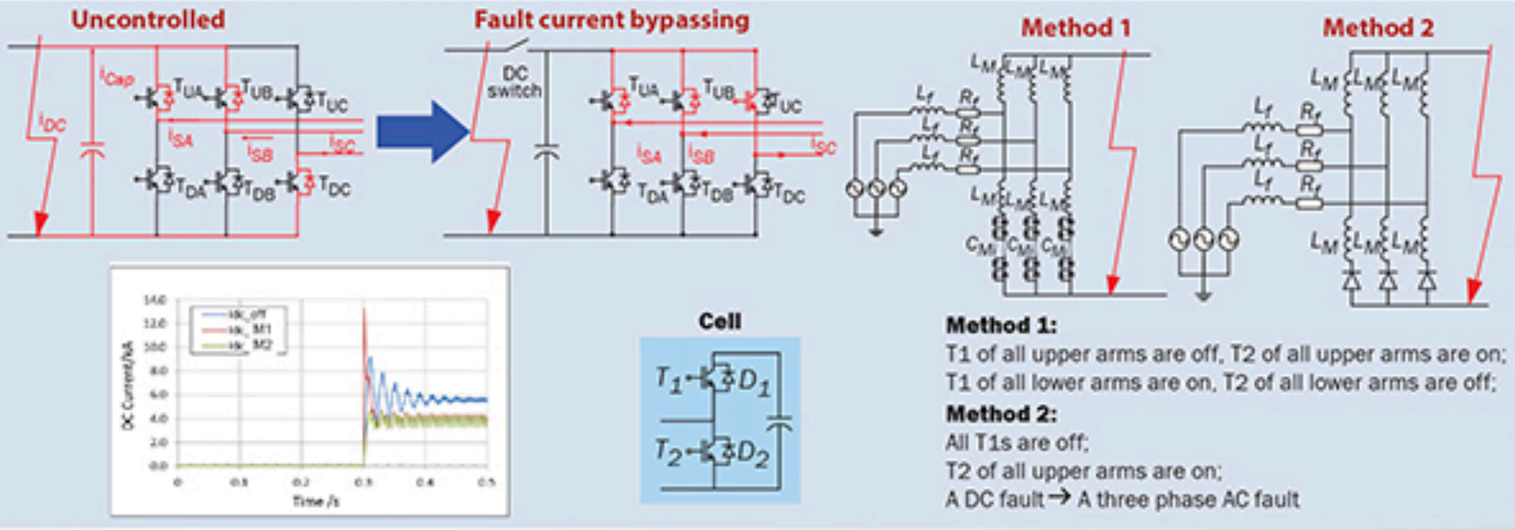
$T_{prot} = T_{det} + T_{del} + T_{lim}(T_{byp}) + T_{cod} + T_{com} + T_{off} + T_{res}$

Speed Requirements

- $i_{int} < i_{convertermax}$
- T_{CCT1}: the maximum time of system under fault
  - $T_{lim}(T_{byp}) + T_{cod} + T_{com} + T_{off} + T_{res} < T_{CCT1}$
- T_{CCT2}: the maximum time of system without supply
  - $T_{cod} + T_{com} + T_{off} + T_{res} < T_{CCT2}$

Converter fault current bypassing

- Conventional converters can bypass DC fault currents.
- PE switches are manipulated to form artificial AC faults at converter terminals in order to avoid DC fault currents.
- High fault currents flow through converters and their upstream systems.

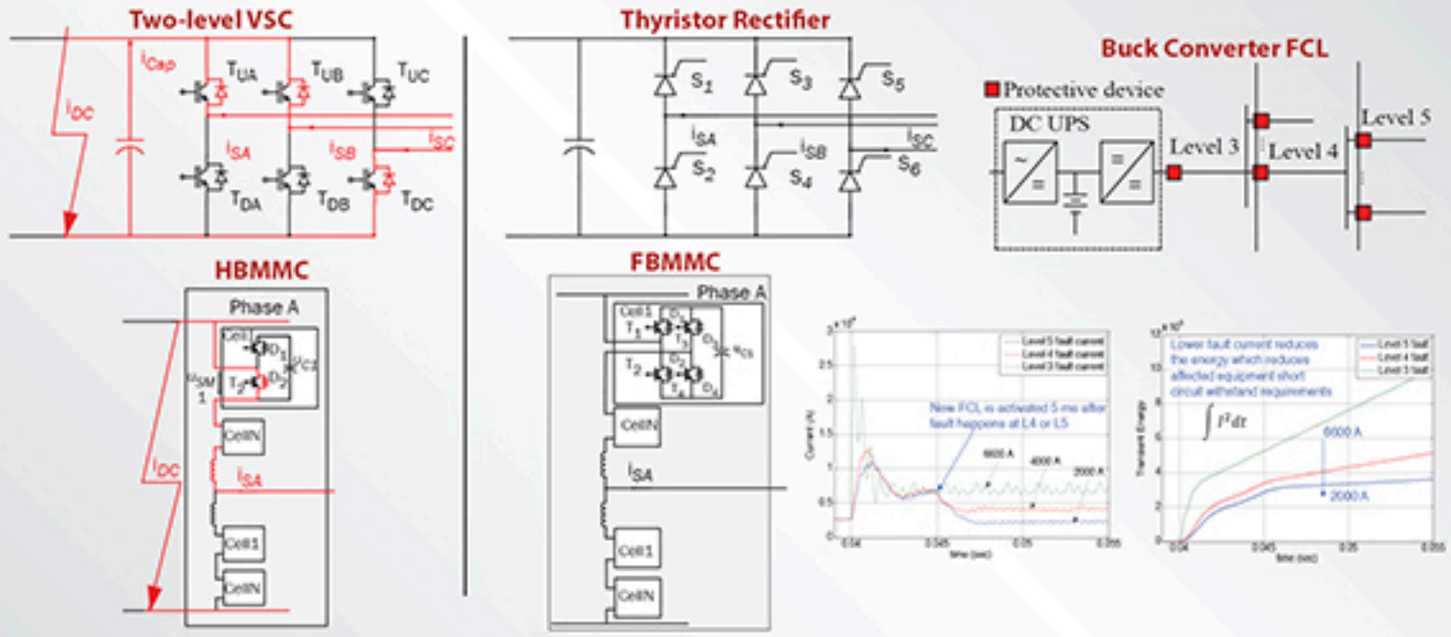


Method 1:
T1 of all upper arms are off, T2 of all upper arms are on;
T1 of all lower arms are on, T2 of all lower arms are off;

Method 2:
All T1s are off;
T2 of all upper arms are on;
A DC fault → A three phase AC fault

Converter fault current limiting

- Most commercially available converters cannot limit DC fault current.
- To limit fault currents, controllable PE switches are required on fault paths.
- FCL converters include: dc-dc buck converter, thyristor rectifier, FBMMC, CDMMC



Conclusion

- A DC fault protection solution can be a proper combination of a solid-state fault current limiting technology applied with a fault isolation technology.
- Selection of appropriate limiting inductors is the key to design solid-state fault current limiters.
- Comparing with fault current bypassing, the converter FCL has lower requirements on device ratings of converters and speeds.
- Shortcomings of converter fault current handling:
  - DC fault currents may not be fully limited due to the filter discharges;
  - Selectivity could be lost;
  - Topology and/or PE switches upgrade is needed;
  - Converters need to be restored after faults;

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