

Multi-function DC protection scheme for an LVDC smart distribution network

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Introduction

Low voltage direct current (LVDC) distribution systems have the potential to support future realisation of smart grids functionality. They do however present significant protection challenges that existing schemes based on DC fuses and conventional circuit breakers cannot manage due to slow device performance. Therefore, this research introduces an advanced protection scheme that addresses the outstanding challenges facing realisation of last mile DC distribution.

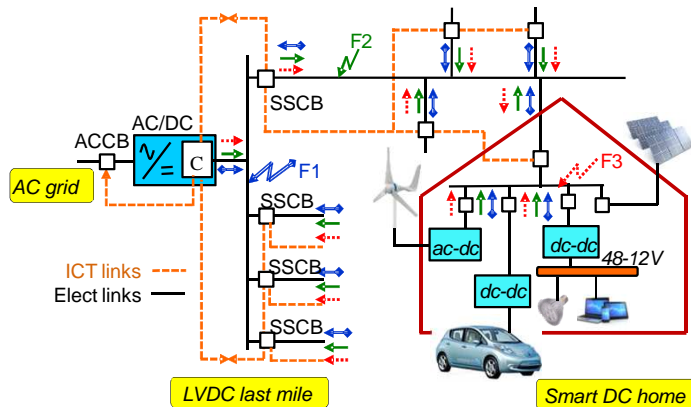
Potential benefits of LVDC systems

- Increased power capacity and reduced energy waste and losses by reducing AC-DC conversion stages
- More suitable for devices generate/consume DC and easier to connect and control multiple sources in parallel
- Increased reliability and flexibility in operation that could offer more flexible market mechanism with better stimulation of customers control demands

LVDC protection issues

- Very high transient DC fault currents
- Slow performance of existing LV protection schemes
- Sensitive devices become defenceless against the high transient DC faults
- The rapid depression of DC voltages leading to unnecessary converter trips, and poor protection selectivity.
- Post-fault high transient spikes of DC voltages
- Sympathetic tripping of local microgeneration against remote DC faults

LVDC last mile distribution network



An LVDC network protected by multi-function protection scheme

Protection functions	Relays	C	IED1	IED2	IED3	IED4
	Current directions	1	0	0	0	0
Trip function		✓	-	-	-	-
Blocking reverse current		-	✓	✓	✓	✓
Reclosing function		-	-	-	-	-

Converter and main feeder relays performance during fault F1

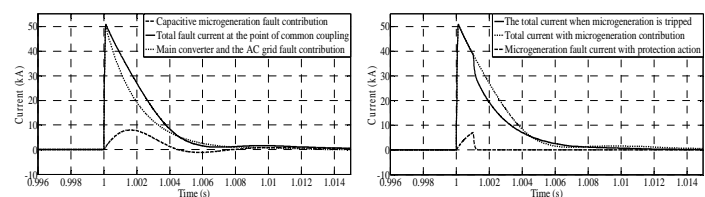
Protection functions	Relays	C	IED1	IED2	IED3	IED4
	Current directions	1	1	0	0	0
Trip function		-	✓	-	-	-
Blocking reverse current		-	✓	✓	✓	✓
Reclosing function		-	✓	-	-	-

Converter and main feeder relays performance during fault F2

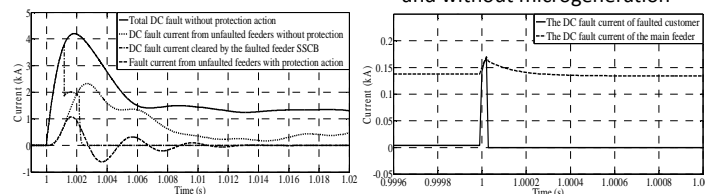
Fast acting protection scheme

- It is communication-assisted with a combination of AC and fast acting electronic-based DC protection
- Fault detection and locations are based on the measurement of DC fault current directions and magnitudes, and DC voltages during DC fault transient periods using multiple IEDs
- Solid state circuit breakers (SSCBs) which can be turned on/off within few microseconds are used for interrupting DC faults.

Simulation results



Pole-pole DC fault behaviour at the PCC and without microgeneration

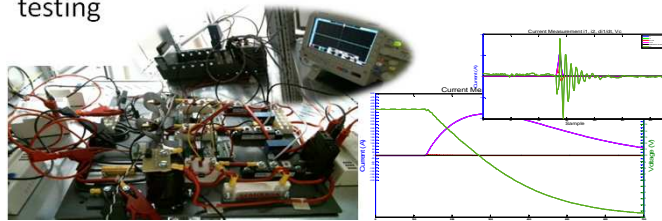


DC discharge fault current with and without protection action

Downstream DC fault cleared by the end user SSCB

DC protection testing rig

- Comprehensive DC faults characterisations have been conducted
- The new protection solution performance with a variety of physical DC faults is under low power testing



Conclusions

- More resilient network performance can be delivered by quickly detecting and interrupting DC faults during transient and within small timescales.
- The fault level is significantly limited
- The local generation ride through capability is improved
- Project now informing a new LVDC code of practice