Ingegneria dei sistemi elettrici

Electric Systems

DII research group

Power System Group

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This research activity is carried out in collaboration with:
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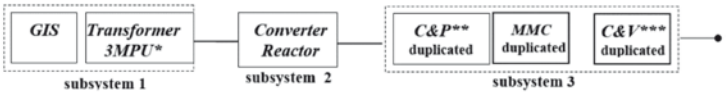
Main research topics:

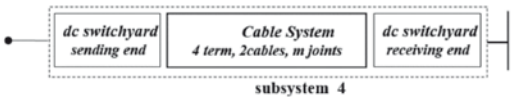
- Large-scale energy storage in the network;
- EHV/HV dc and ac innovative transmission lines e.g. insulated cables and gas insulated lines;
- Synergy between railway and highway infrastructures and insulated cables;
- Multiconductor cell analysis (MCA) of asymmetric systems by means of self-implemented matrix procedures (insulated cables with screens and armours, gas insulated lines with enclosures, overhead lines with one or more earth wires);
- Availability assessment of whole HVDC-VSC links
- Sinergy between insulated cable power transmission systems and transport infrastructures;
- Smart grids: the operation and control of active networks;
- Voltage regulation in the distribution network with high penetration of distributed generation.

High Voltage Direct Current electric lines in the transmission grids of the future

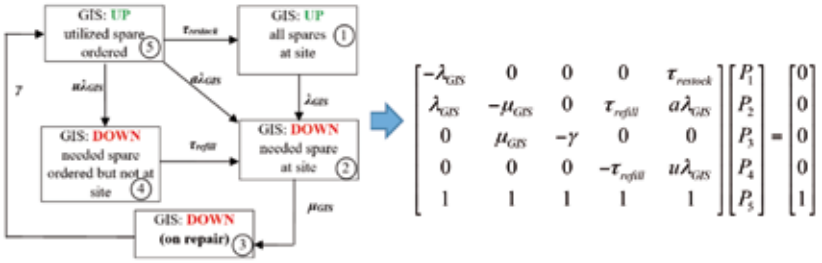
HVDC-VSC transmission gains growing interest for its capability of providing multiple vital services within electrical power networks in the form of supply of reactive power and other ancillary services, which can be secured even if an outage interrupts the transmission function itself. This research focuses on the development of analytical methods for availability/unavailability assessment of HVDC-VSC point-to-point connections and on the study of the compatibility between HVDC systems and transport infrastructures. The Key reliability features of modular multilevel converters (MMC) are taken into account by means of closed-form reliability equations, and combined with the Markov state-space models of each component of the HVDC system in order to asses the whole system availability. The possibility of correctly estimating the availability of HVDC systems is becoming more and more important, especially when highway and railway infrastructures (planned or existing) are exploited in order to install HVDC insulated cables. In fact, different services hosted into the same infrastructures require accurate availability analyses to efficiently manage the structure itself. A practical application of these concepts is represented by the ±320 kV HVDC VSC interconnection between France and Italy named "Piedmont-Savoy" which will constitute a further strengthening of the Pan-European grid. This cross-border interconnection will be mostly hosted on the existing highway infrastructures.



Border interconnection will be mostly hosted on the existing highway infrastructures



Block diagram of a whole HVDC-VSC symmetrical monopole



Example of Markov state-space model approach: HVDC GIS subsystem and the related probabilistic matrix

Symmetrical monopole component	*Availability (steady-state)*	*Unavailability*	*Mean Outage Time [hrs/year]*
GIS	0.9997	$2.9303 \cdot 10^{-4}$	2.57
Transformer	0.9996	$3.1650 \cdot 10^{-4}$	2.77
Converter Reactor	0.9971	0.0029	25.4
Converter (incl. C&V)	0.9986	0.0014	12
Cable Circuit (105 km)	0.9700	0.02991	262.01
dc Switchyard (Swy)	0.9993	0.0007	6.13
Cable Ct.+ 2 terminals	0.9687	0.03131	274.28
Whole Link	**0.9666**	**0.0334**	**292.58**

Availability assessment of the whole HVDC link

HVDC power cables installed in highway infrastructure in the future Piedmont-Savoy intertie