Transient Investigations of Earthing and Equipotential Bonding Systems for HVDC Power Transmission Cables

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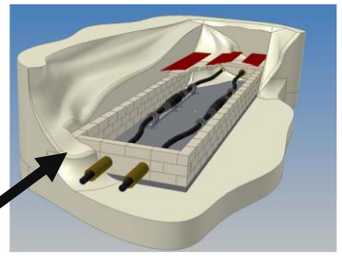
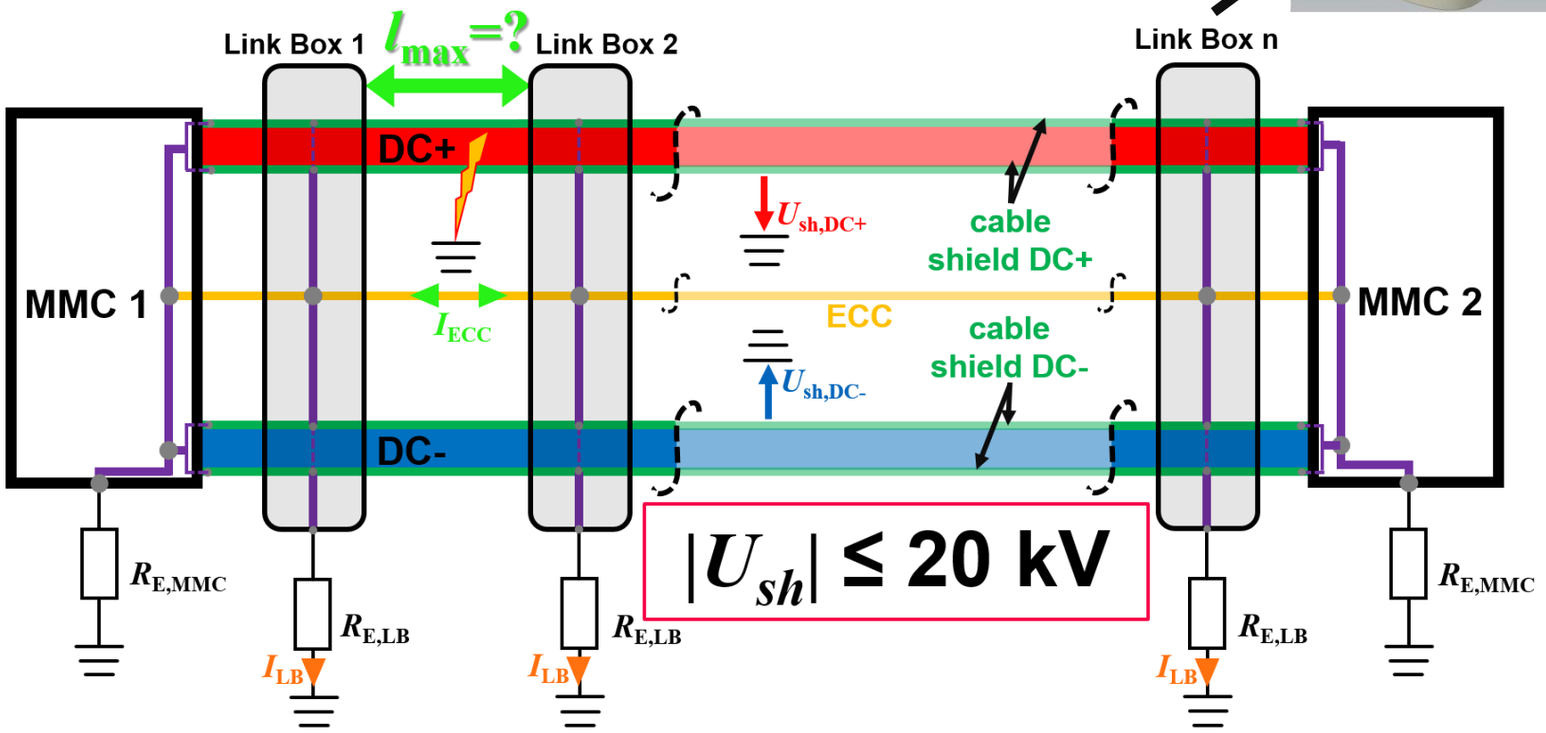
SCIENCE
PASSION
TECHNOLOGY

ELECTRICAL
POWER SYSTEMS
TU GRAZ

Simulation Model (I) – Basic



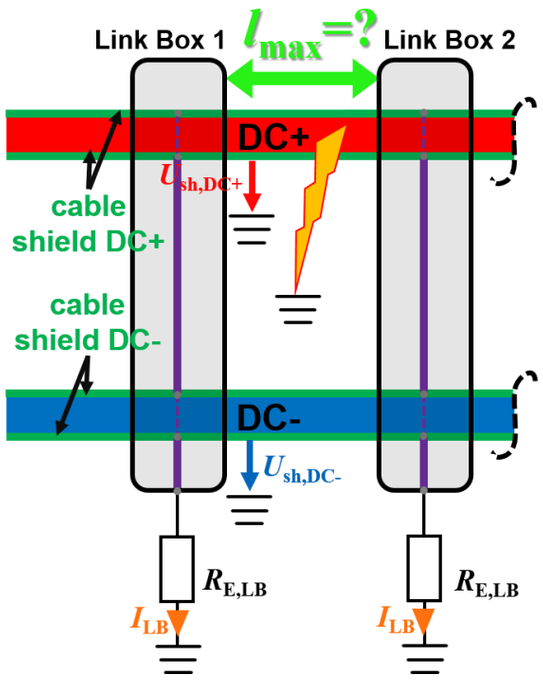


Legend:

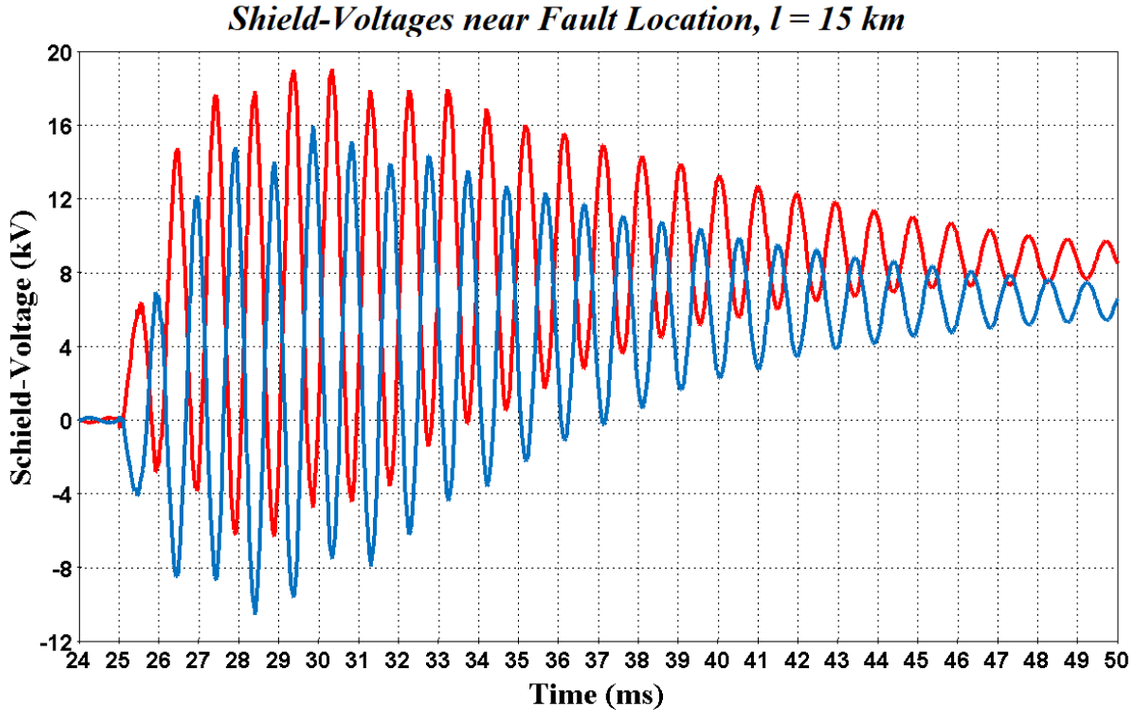
MMC…Modular Multilevel Converter $R_{E,MMC}$…Earth Resistance MMC $R_{E,LB}$…Earth Resistance Link Box
U_{sh}…Shield-Earth-Voltage l_{max}…Maximum distance between Link Boxes

- Technical specifications:
  - **400 km**
  - **2 GW**
  - **500 kV (DC)**
- Transient stress during an earth fault?
- Maximum distance between link boxes?
- Influence of an Earth Continuity Conductor (ECC)?

Earth Fault **without** Earth Continuity Conductor (ECC)

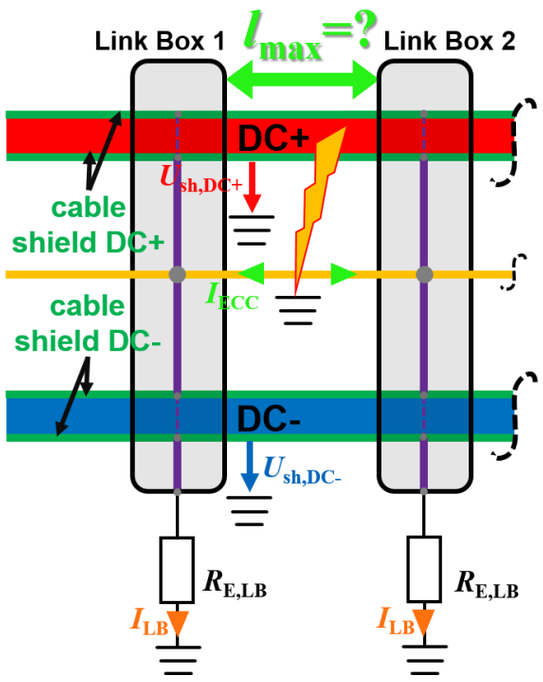


$|U_{sh}| \leq 20$ kV

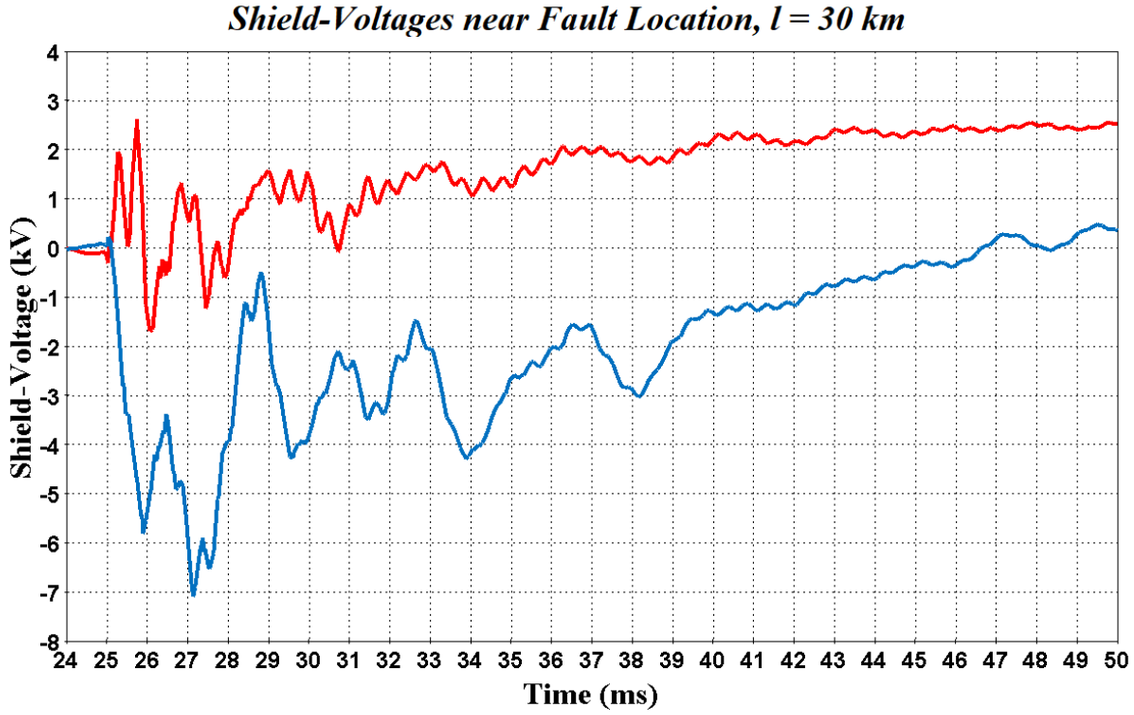


- **25** link boxes necessary
- l_{max} = **15** km
- Longer l → higher I_{LB}
- High requirements on earthing concpet of link boxes

Earth Fault **with** Earth Continuity Conductor (ECC)

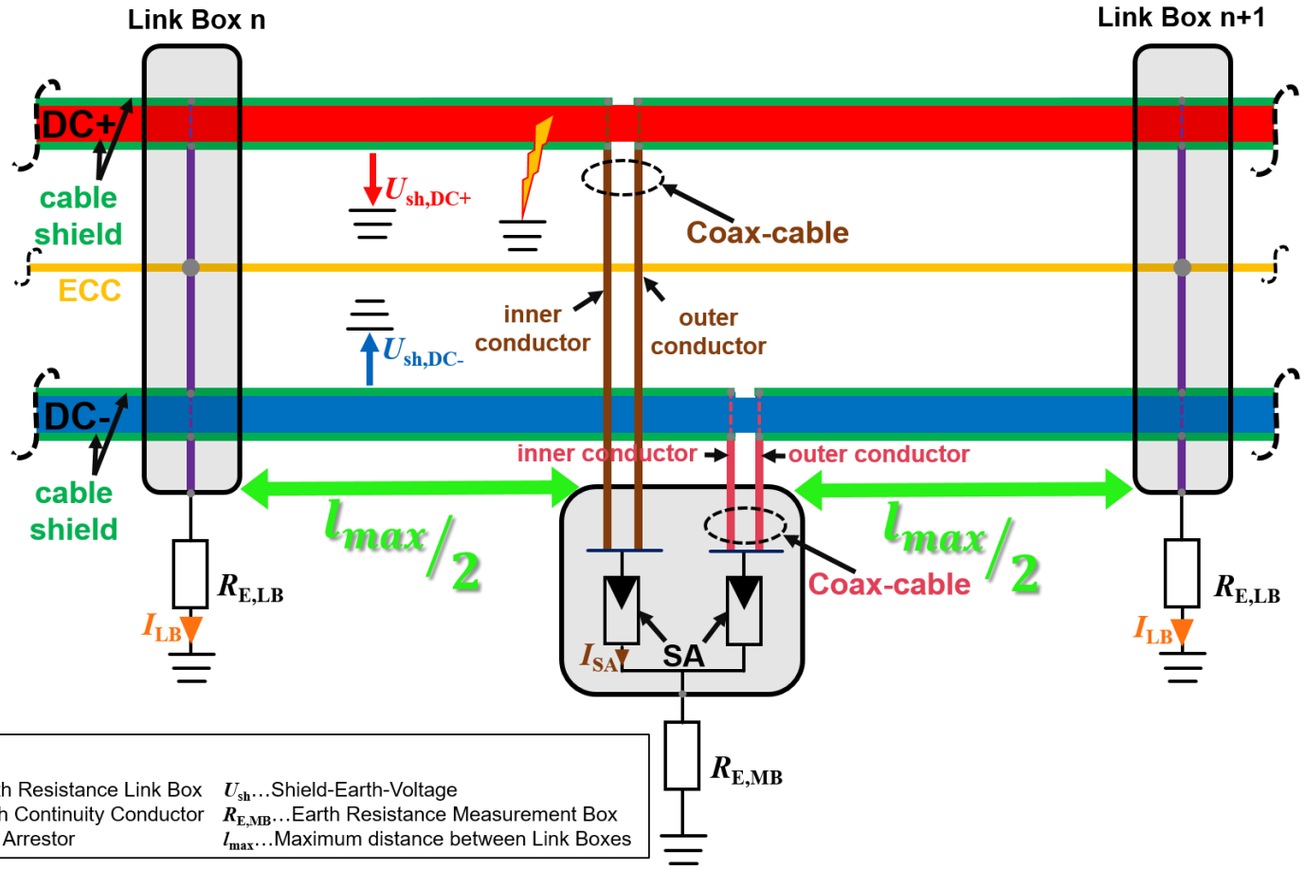


$|U_{sh}| \leq 20$ kV



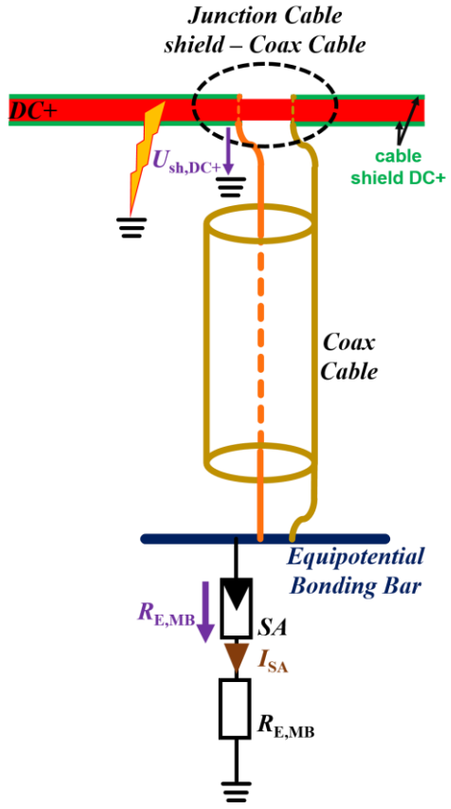
- **12** link boxes necessary
- l_{max} = **30** km
  (set due to lightning protection)
- ECC has potential equalising effect
- ECC distributes fault current on other link boxes

Simulation Model (II) – Extension by Measurement Boxes



Legend:

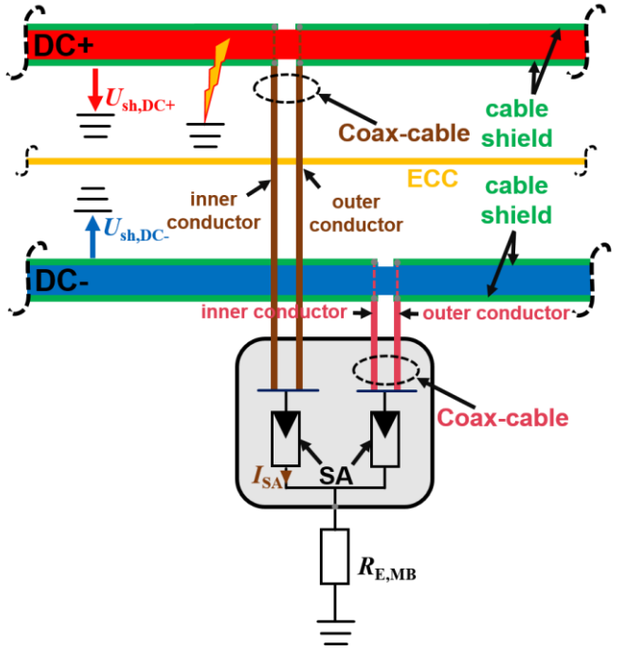
$R_{E,LB}$…Earth Resistance Link Box	U_{sh}…Shield-Earth-Voltage
ECC…Earth Continuity Conductor	$R_{E,MB}$…Earth Resistance Measurement Box
SA…Surge Arrestor	l_{max}…Maximum distance between Link Boxes

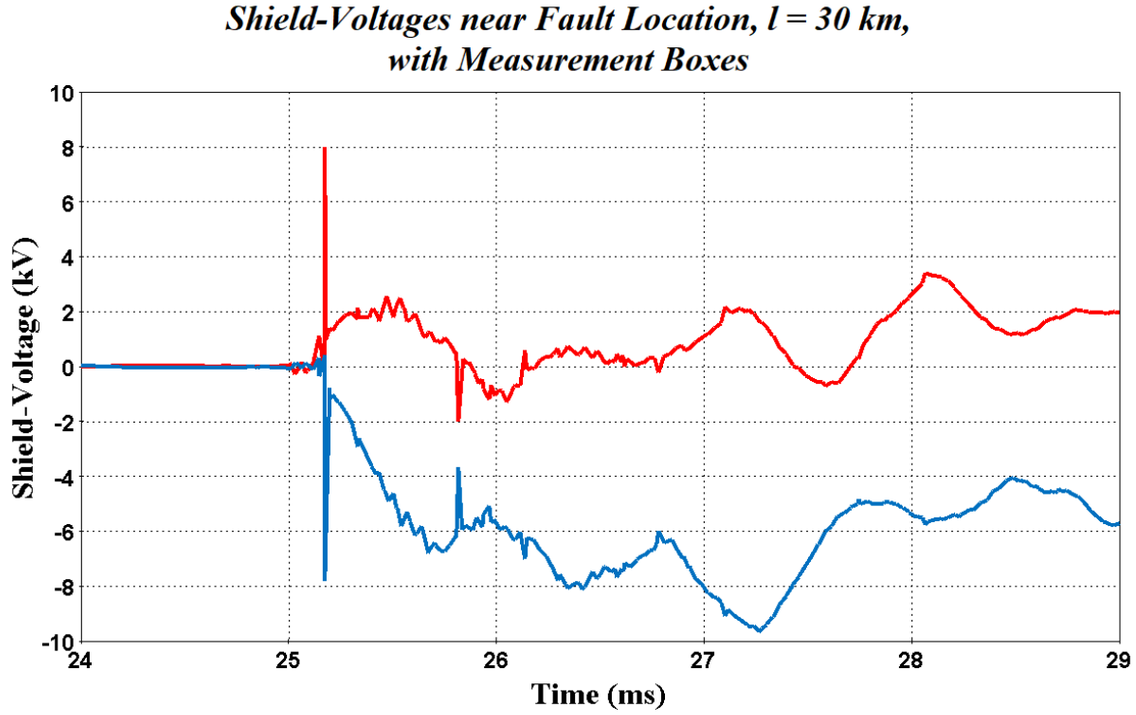


- Influence of
  - Coax-Cable
  - Surge Arrestor
- Maximum distance between link boxes?

$$|U_{sh}| \leq 20\ \text{kV}$$

Earth Voltages nearby Measurement Box





$|U_{sh}| \leq 20$ kV

- Reflection points:
  - Cable shield – coax cable
  - Equipotential
- l_{max} = **30** km (set due to lightning protection)
- ECC has potential equalising effect
- ECC distributes fault current on other link boxes

Conclusions

Without ECC:

- Maximum permissible shield voltage defines the distance between the link boxes
  - Higher Acquisition and
  - maintenance costs

With ECC:

- Less link boxes required
- Lower demands on earthing concept of link boxes

With Measurement Boxes:

- Weak spot is juction cable shield – coax cable
- High transient stress at equipotential bonding bar