1. Document History

Date	Versions	Description	Author
15-04-2021	0.1	First draft version	Petra Raussi (VTT)
10-06-2021	1.0	Second draft focused on selected Distribution System	Gunter Arnold (IEE)
25-10-2021	1.1	Draft updated with communication network configuration	Vetrivel (TUD)

2. General description

2.1 System configuration identification

ID	Name
JRA1-EICT-DIST	JRA1 Electrical + ICT benchmark for distribution system

2.2 Short description of context

Context description
The system configuration described in this document has been developed as part of a reference setup for IT and electrical system simulations. This reference setup intends to inspire the use of co-simulation for the assessment of combined communications and power system configurations. The level of detail was chosen in a way that allows to apply different modelling approaches for the individual subsystems. For instance, the communication network could be implemented either as point-to-point communication or as a full topology.
Key figures

• CIGRE MV Benchmark power system model with:
  ○ 1 external HV network,
  ○ 1 HV bus
  ○ 1 MV Filter / Capacitor bank
  ○ 2 HV/MV OLTC Transformers
  ○ 14 MV busses
  ○ 14 Lines
  ○ 18 MV loads
  ○ 8 PV systems
  ○ 1 Wind turbine
• Communication network of a digital substation with following topology:
  ○ 6 hosts/nodes that represent field devices such as remote terminal units, merging units, intelligent electronic devices, etc.
  ○ 3 Ethernet switches
  ○ 1 gateway to control centre
• control algorithm: coordinated voltage control application,
• 3 categories of coupling/interfacing: real-time, non-real-time and hardware based

Key words
• CIGRE MV Benchmark power system model • Communication network • Coordinated voltage control

2.3 Climate

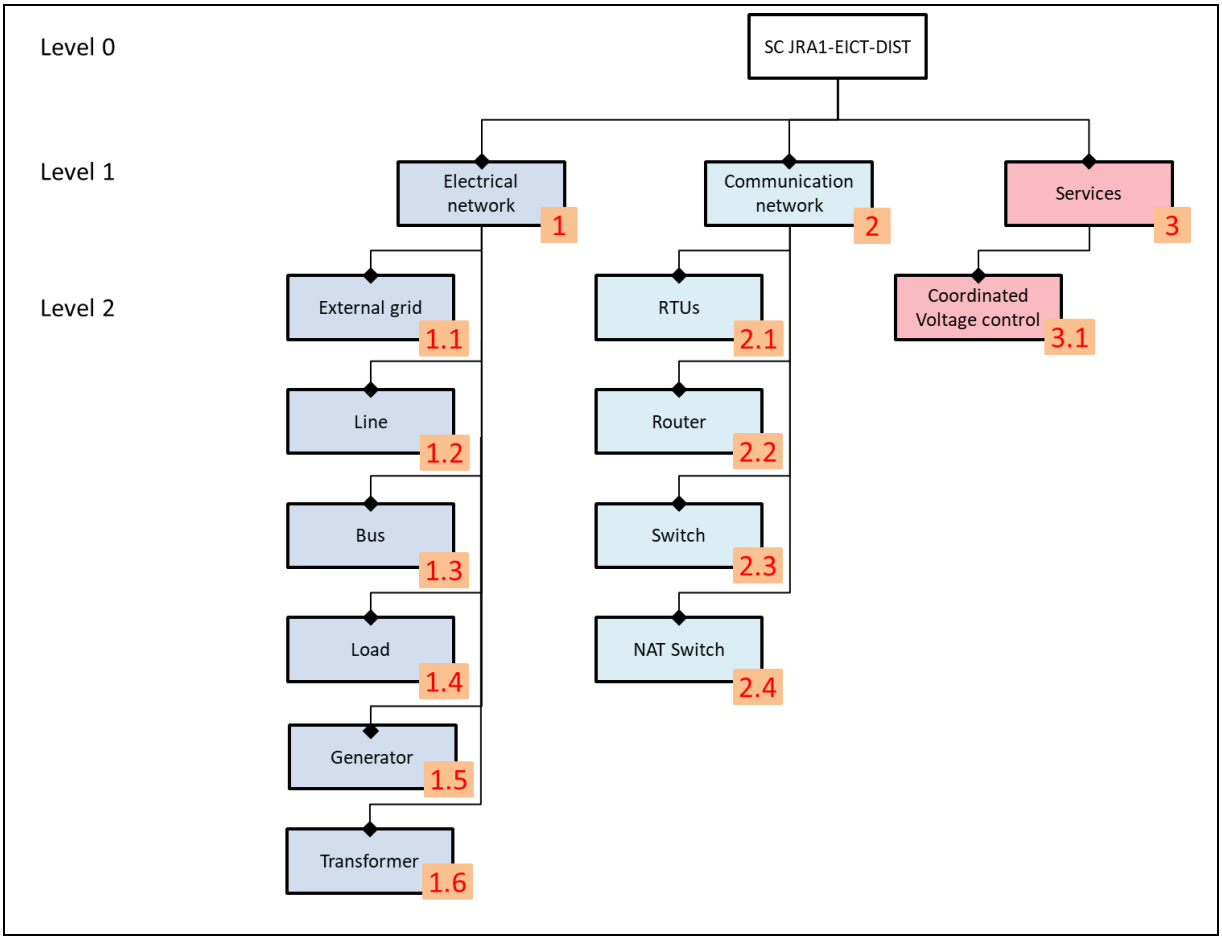
Climate conditions
Not relevant for this system configuration.

Files attached		
File ID	Description	Units

2.4 Geographical features

Geographical features
Distribution grid power system based on CIGRE MV Benchmark model. Focus especially on substations.

3. System breakdown (SBD)

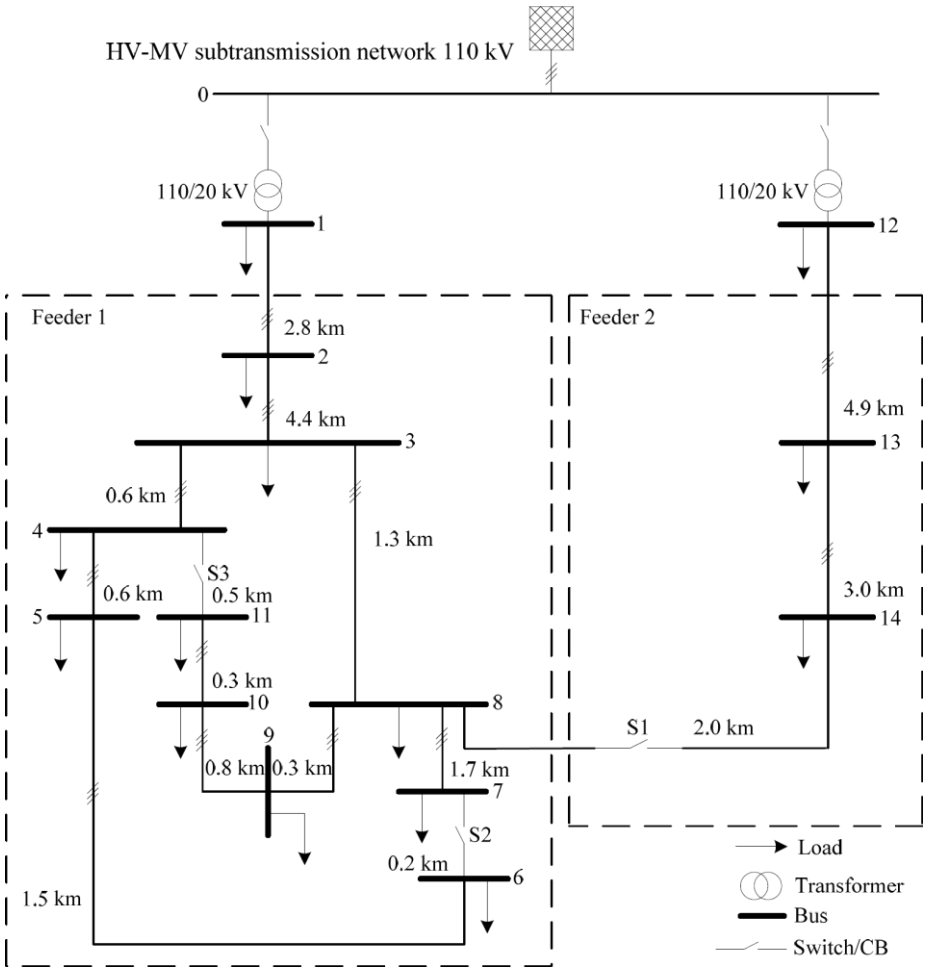


4. Graphical representations of SC

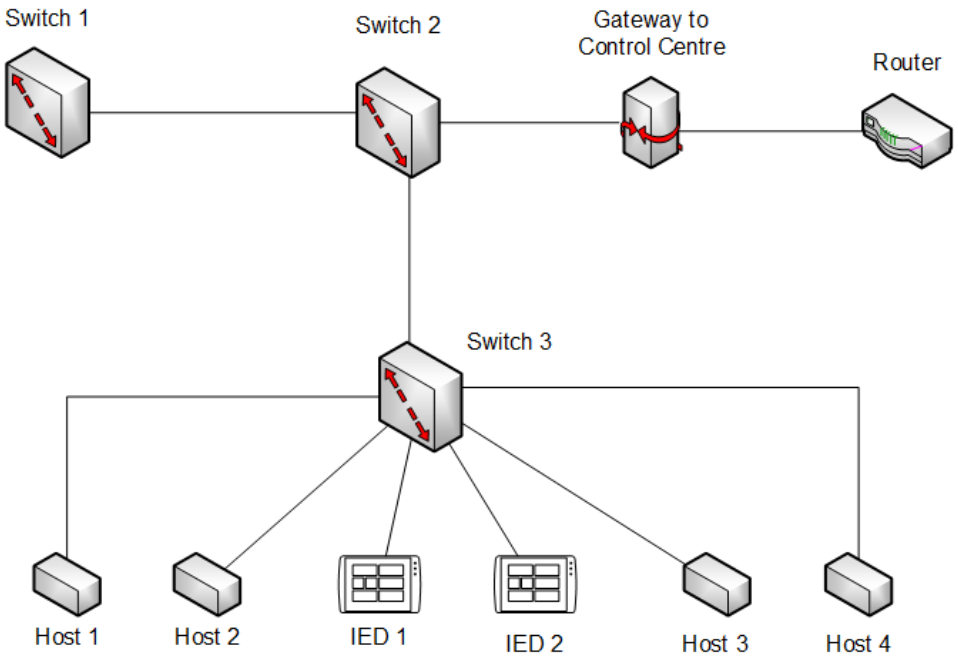
4.1 Network diagrams

Electric power system – CIGRE MV Benchmark model

Only feeder 1 is considered in this benchmark



Communication network (detailed view)



5. Element connections

Name	ID	Type of exchange	Types of class connected	Comment
Communication port	CommPort	Interface for communication flow		
Electric power port	ElectricPort	Interface for electric power flow		

6. Elements description

Replicate the following table for every element in the SBD

About	
ID in SBD	1
Level in SBD	1
Class name	Electrical Network
Parent class	-
Contained in	JRA1-EICT-DIST
Description	This element represents an interconnection of electrical components on HV and MV level.
Number of elements in SC	1
Attributes	
Functionality	An electric network contains interconnected components with the purpose of delivering electricity from producers /generators to consumers / loads.
Physical characteristics	U_n (Float) – Nominal voltage [Volt] f_n (float) - Nominal frequency [Hz]
Surroundings	-
Quality	-
Support	-
Operation type	-
Economical features	-
Legal constraints	-
Instances characterization	
Interfaces	-

ID in simulation	elNet
Files attached	

About	
ID in SBD	1.1
Level in SBD	2
Class name	ExternalGrid
Parent class	-
Contained in	elNet
Description	This element is used to represent an external/higher level electrical power system.
Number of elements in SC	1
Attributes	
Functionality	The external grid controls the voltage and the phase angle of the MV feeder to which it is connected.
Physical characteristics	-
Surroundings	-
Quality	-
Support	-
Operation type	-
Economical features	-
Legal constraints	-
Instances characterization	
Interfaces	port (ElectricPort) - bus where the external grid is connected
ID in simulation	extElGrid
Files attached	

About	
ID in SBD	1.2
Level in SBD	2
Class name	Line
Parent class	-
Contained in	elNet
Description	This element is used to represent cables or overhead lines of an electric power system.

Number of elements in SC	14
Attributes	
Functionality	Lines are used to connect two nodes/buses of an electric power system.
Physical characteristics	l (float) - Line length [km] r (float) - Resistance [Ω/km] x (float) - Reactance [Ω/km] c (float) – Capacitance [nF/km] or B (float) – Susceptance [µS/km] i_r (float) - Rated current [kA]
Surroundings	-
Quality	-
Support	-
Operation type	-
Economical features	-
Legal constraints	-
Instances characterization	
Interfaces	port_a (ElectricPort) - bus no. on one side to which the line will be connected port_b (ElectricPort) - bus no. on the other side to which the line will be connected
ID in simulation	Line 07-08
Files attached	

About	
ID in SBD	1.3
Level in SBD	2
Class name	Bus
Parent class	-
Contained in	elNet
Description	Buses are the elements of an electric power system to which other elements can be connected.
Number of elements in SC	15
Attributes	
Functionality	A bus connects the lines, generators, loads, etc. to the electric power system.

Physical characteristics	vn (float) - nominal voltage [V]
Surroundings	-
Quality	-
Support	-
Operation type	-
Economical features	-
Legal constraints	-
Instances characterization	
Interfaces	port (ElectricPort) - bus to which other electrical power system components can be connected
ID in simulation	e.g., Bus 01
Files attached	

About	
ID in SBD	1.4
Level in SBD	2
Class name	Load
Parent class	-
Contained in	elNet
Description	Component of the electrical power system that consumes electric power.
Number of elements in SC	18
Attributes	
Functionality	Each load represents an aggregation of the power consumption of several consumers (e.g., households connected to an MV feeder).
Physical characteristics	vn (float) - nominal voltage [V] p (float) – active power consumption q (float) – reactive power consumption
Surroundings	-
Quality	-
Support	-
Operation type	-
Economical features	-
Legal constraints	-
Instances characterization	

Interfaces	port (ElectricPort) – bus to which other electrical components can be connected
ID in simulation	e.g., Load 08
Files attached	

About	
ID in SBD	1.5
Level in SBD	2
Class name	Generator
Parent class	-
Contained in	elNet
Description	Component of the electrical power system that generates electric power.
Number of elements in SC	9
Attributes	
Functionality	Each load represents an aggregation of the power consumption of several consumers (e.g., households connected to an MV feeder).
Physical characteristics	vn (float) - nominal voltage [V] p (float) – active power generation q (float) – reactive power generation
Surroundings	-
Quality	-
Support	-
Operation type	-
Economical features	-
Legal constraints	-
Instances characterization	
Interfaces	port (ElectricPort) – bus to which other electrical components can be connected
ID in simulation	e.g., Gen 02
Files attached	

About	
ID in SBD	1.6

Level in SBD	2
Class name	Transformer
Parent class	-
Contained in	elNet
Description	This element is used to connect two different voltage level in AC power systems and to enable the power flow between these two voltage levels.
Number of elements in SC	2
Attributes	
Functionality	The transformer connects the voltage level of the node at the primary side to the voltage level of node at the secondary side.
Physical characteristics	sn (float) – rated apparent power [MVA] vn_hv (float) – rated voltage on high voltage side [kV] vn_lv (float) – rated voltage on low voltage side [kV] vk_percent (float) – relative short-circuit voltage [%] vkr_percent (float) – real part of short-circuit voltage [%] pcu (float) – iron losses [kW] i0_percent (float) – open loop losses in percent of rated current [%] v_tap [%] – voltage per tap shift (float) – transformer phase shift angle [°]
Surroundings	-
Quality	-
Support	-
Operation type	-
Economical features	-
Legal constraints	-
Instances characterization	
Interfaces	port_hv (ElectricPort) - bus on the high-voltage side to which the transformer will be connected port_lv (ElectricPort) - bus on the low-voltage side to which the transformer will be connected
ID in simulation	Transf xx
Files attached	

About	
ID in SBD	2
Level in SBD	1

Class name	CommunicationNetwork
Parent class	-
Contained in	JRA1-EICT
Description	This element represents the communication network used to transfer, process, and access data.
Number of elements in SC	9
Attributes	
Functionality	A communication network contains interconnected components, i.e., nodes with links to exchange information
Physical characteristics	-
Surroundings	-
Quality	-
Support	-
Operation type	-
Economical features	-
Legal constraints	-
Instances characterization	
Interfaces	-
ID in simulation	commNet
Files attached	-

About	
ID in SBD	2.1
Level in SBD	2
Class name	CommunicationNetworkNodes
Parent class	-
Contained in	commNet
Description	
Number of elements in SC	9
Attributes	
Functionality	The communication infrastructure consists of emulated IT/OT components within a substation as hosts/nodes.
Physical characteristics	
Surroundings	-
Quality	-

Support	-
Operation type	-
Economical features	-
Legal constraints	-
Instances characterization	
Interfaces	IP address of individual node, e.g., `10.0.6.11/16`
ID in simulation	commNetNodes
Files attached	

About	
ID in SBD	2.2
Level in SBD	2
Class name	Links
Parent class	-
Contained in	commNetLinks
Description	This element is used to transport data from one port to the other and thereby physically or logically connecting two elements of a communication network.
Number of elements in SC	9
Attributes	
Functionality	This element represents the communication links used to transfer, process, and access data.
Physical characteristics	
Surroundings	-
Quality	-
Support	-
Operation type	-
Economical features	-
Legal constraints	-
Instances characterization	
Interfaces	eth0 (Ethernet Port) – interface port to send and receive packets
ID in simulation	
Files attached	