Introduction to IBR Plant Model Construction

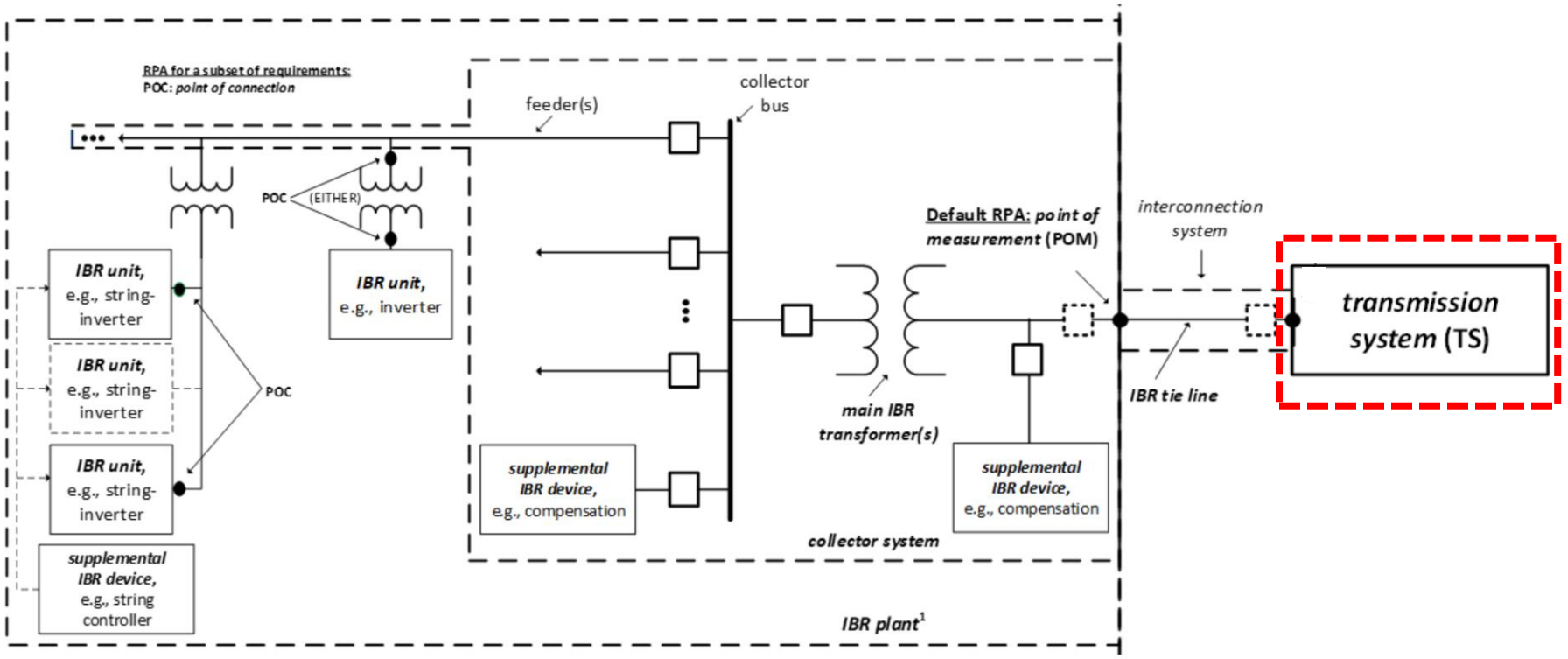
ESIG
ENERGY SYSTEMS INTEGRATION GROUP

Fundamentals of IBR Plant Model Construction

- **What is the purpose of creating IBR plant models?**
  - **At a high level:** To represent the behavior of the IBR plant during normal and abnormal conditions
    - We need to know how an IBR plant will behave under certain conditions and stimuli
  - **Digging in:** There are numerous ways to represent an IBR plant including:
    - Aggregate
    - Disaggregate
    - Generic/standard
    - Vendor-specific
  - **Key consideration:** How you represent the IBR plant in the model space should be considered based on the goals and purpose for the study work being conducted
    - **Choose two of the following:** (1) Quick study (time and computation); (2) Accuracy; (3) Cost

Components of an IBR Plant – Transmission System

IBR Plant model creators (developers, consultants, OEM) do not often have access to transmission system models

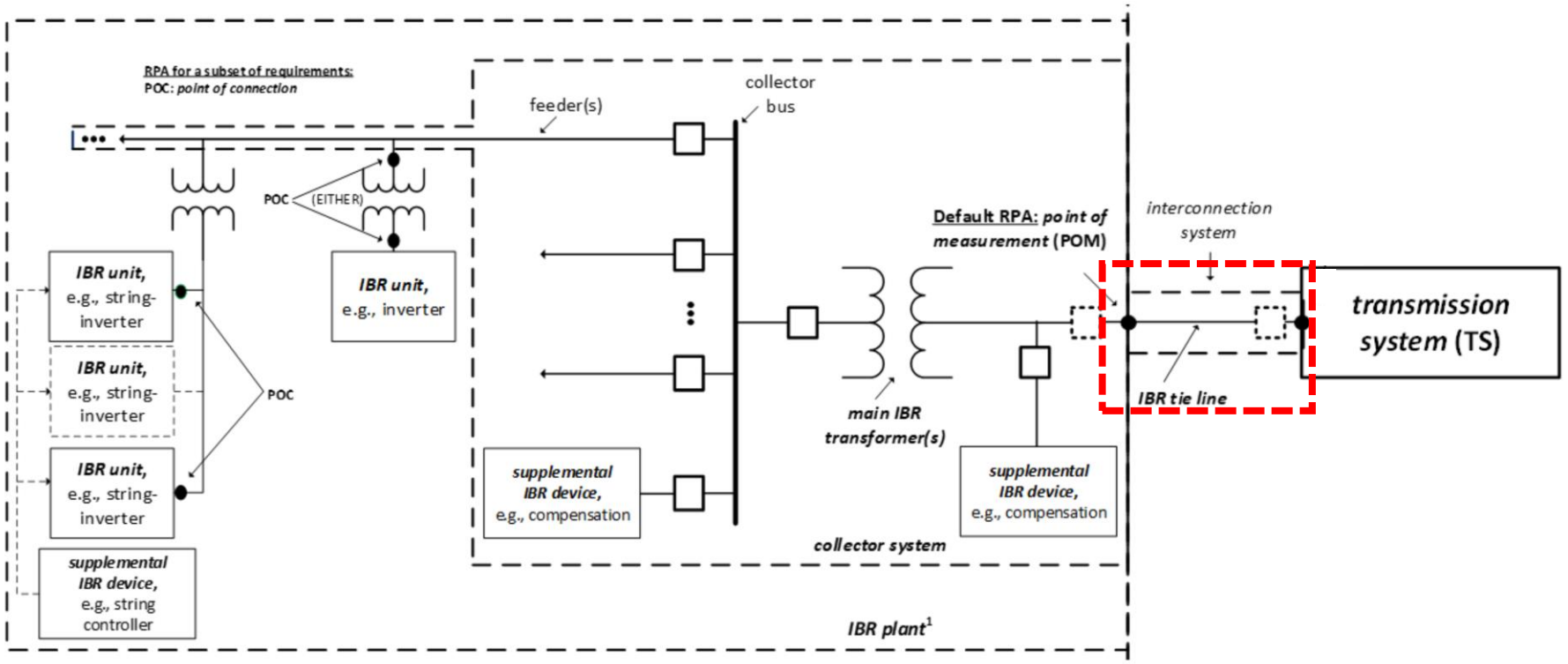


- Equivalent networks are used in place of the transmission system
- Single machine infinite bus (SMIB) are often used
  - Can be adapted to approximate some TS conditions:
    - SCR
    - X/R ratio
    - System impedance
- Data comes from utility, TO, TP, PC
  - Point of contact at the interconnecting utility should be able to provide sufficient information

Source: Adapted from IEEE 2800-2022

Components of an IBR Plant – IBR Tie Line

IBR tie lines are often ”ignored” due to typically very short lengths

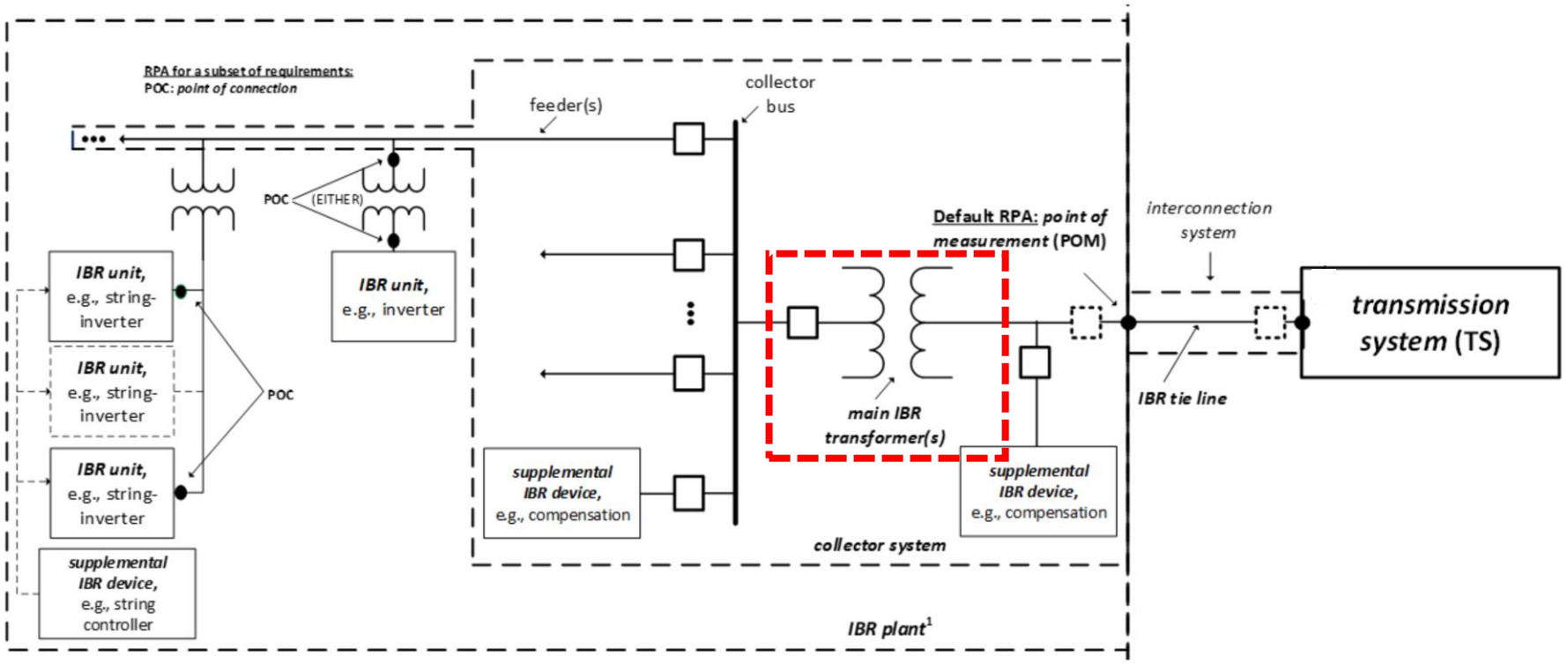


- Many IBR tie lines are extremely short (hundreds of feet) and their impedance is often not included
- Tie lines are important outside of just their impedance
  - Different regional requirements apply at sending or receiving end of tie line
  - Tie lines are often used for controller feedback in the model space
- Data comes from IBR plant developer or their consultant:
  - Construction drawings
  - Cable schedules
  - Cable cutsheets

Source: Adapted from IEEE 2800-2022

Components of an IBR Plant – Main Power Transformer

Main IBR transformers: also known as main power transformers (MPT) are frequent causes of incorrect representation

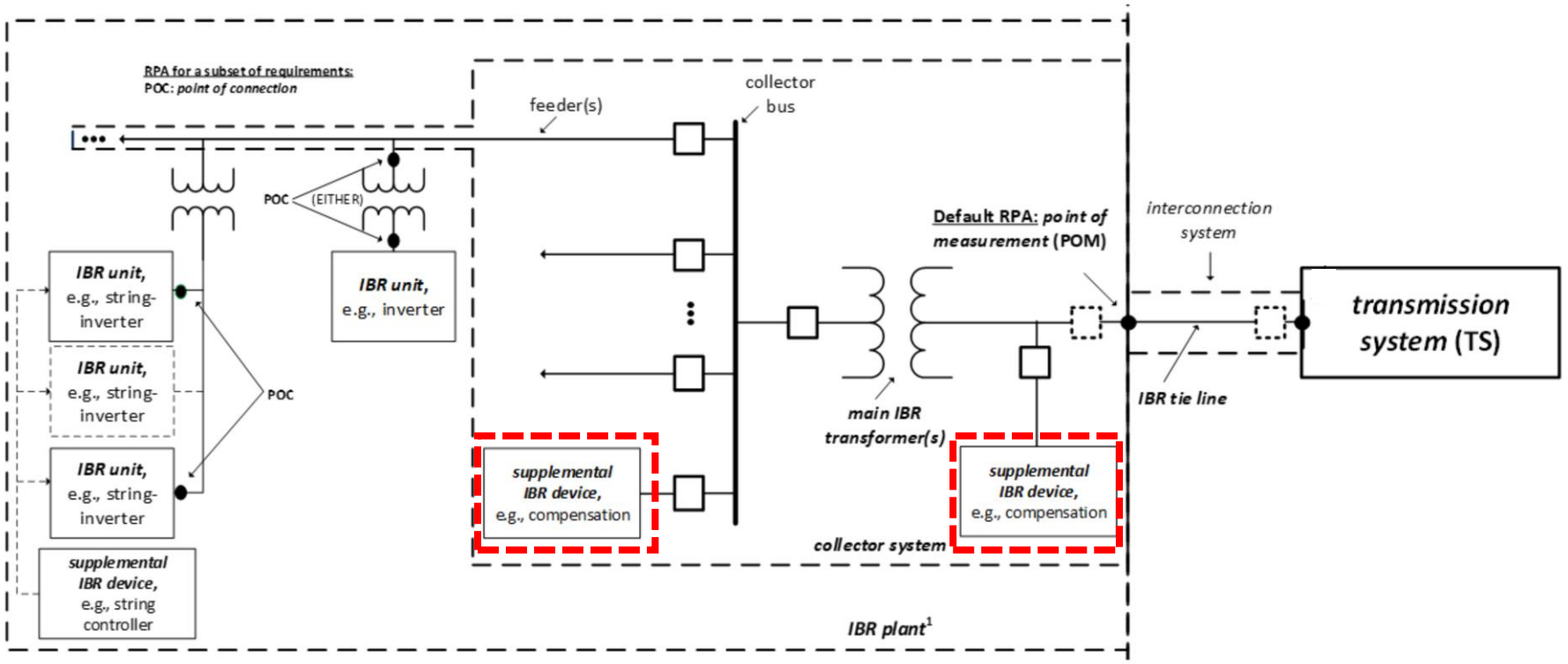


Source: Adapted from IEEE 2800-2022

- MPT are important control devices at the IBR Plant
  - Offload tap changers
  - Onload tap changers
    - Deadbands, step size, step number
- Transformer characteristics are crucial
  - Impedance base in the software may be default or specified
  - Transformer documentation can be confusing
  - Prone to data errors when moving between software tools
- Simulations often are not run long enough to incorporate MPT dynamics
- Data comes from IBR plant developer or their consultant
  - Factory Acceptance Tests
  - Saturation characteristics

Components of an IBR Plant – Supplemental Devices

Supplemental devices are often critical when representing IBR performance and capability

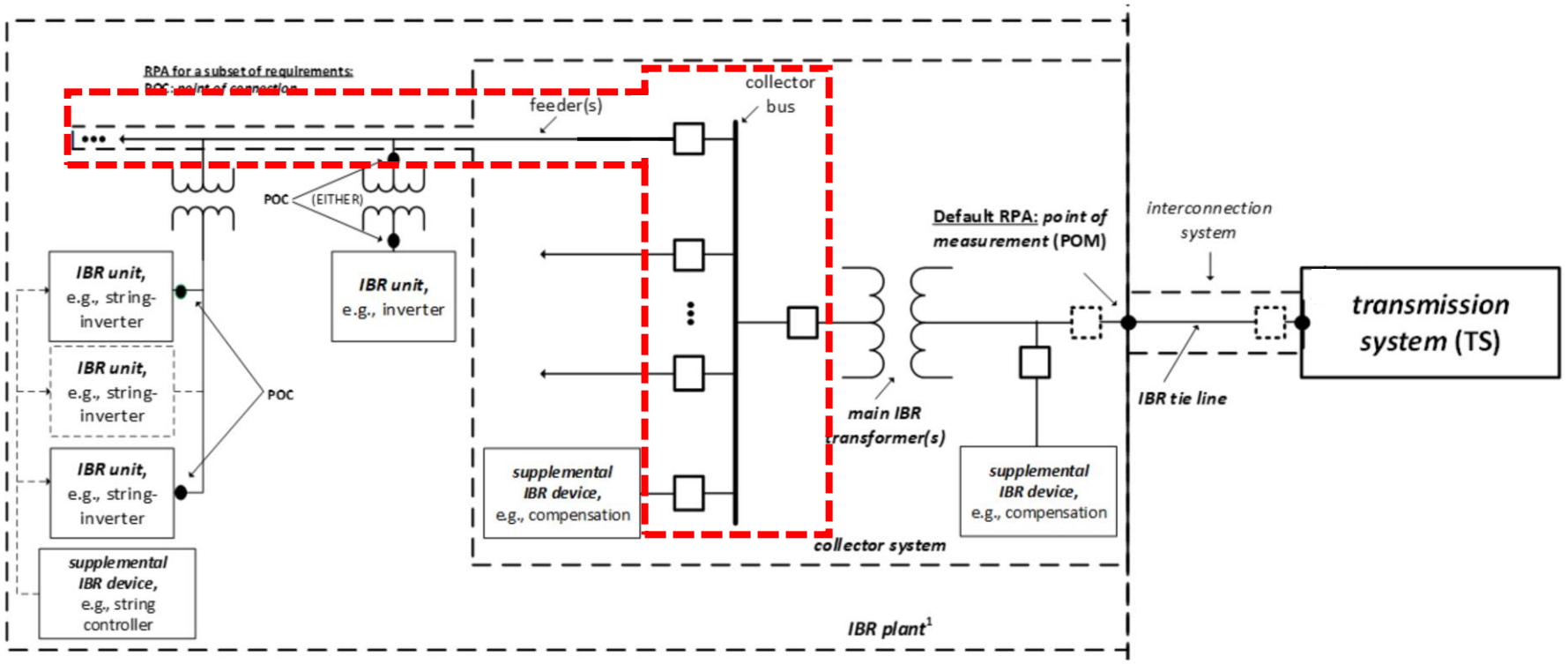


Source: Adapted from IEEE 2800-2022

- Supplemental devices add additional capabilities to the IBR Plant design
  - Fixed shunts (capacitors or reactors)
  - Switched shunts
  - Communication devices
    - Time delays and sample times
- In steady state:
  - Represent size and type of device to be used for capabilities
- In dynamics:
  - Need to consider communication, stepping logic, triggers, and other controls
- Data comes from developer or their consultant
  - Control drawings
  - Construction drawings
  - Third party control vendors

Components of an IBR Plant – Collector System

Collector systems vary widely among different types of IBR plants, but general layout is the same

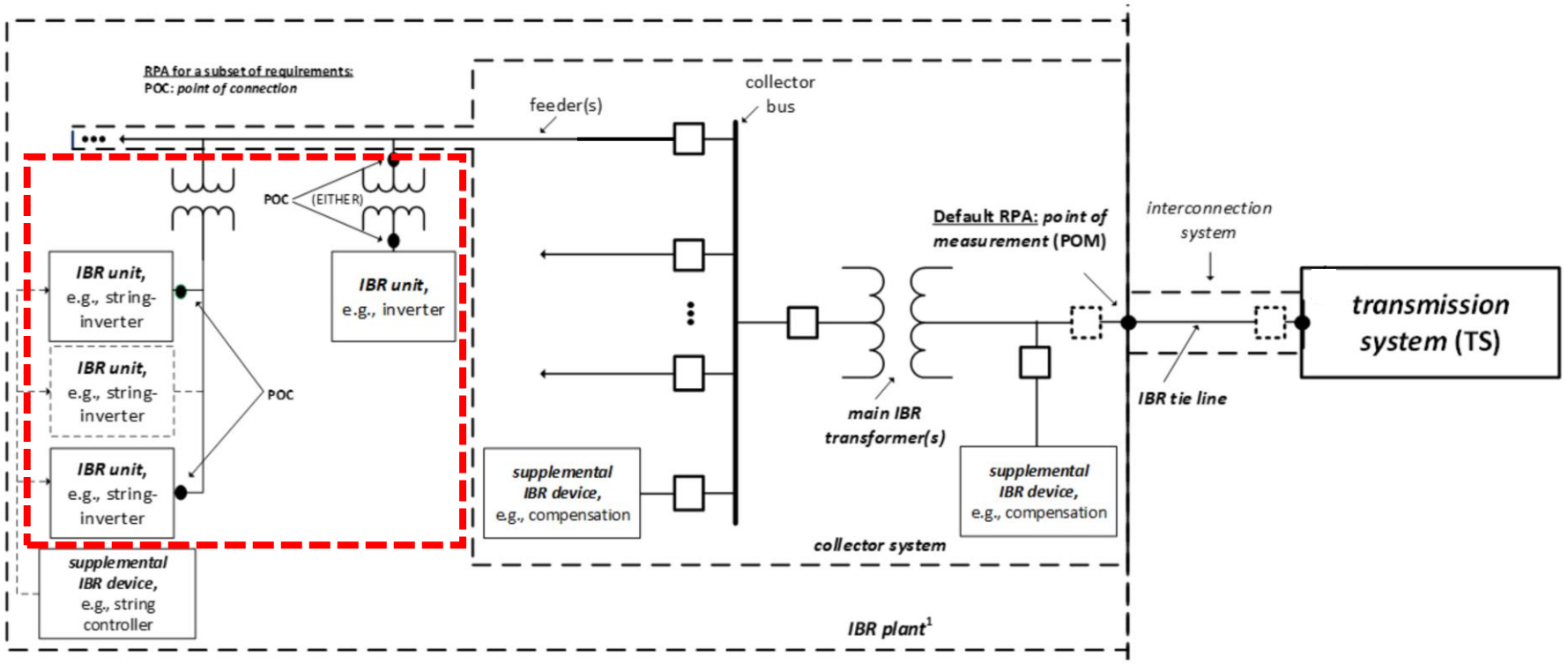


- Composed of numerous components
  - Substation collector buses
  - Cable sections and junctions
  - Protective relays
- With so many components, errors are easy to make
  - Incorrect cable types
  - Incorrect distance data
  - Problems with in-house automation and aggregation
- Data comes from developer or their consultant
  - Construction drawings
  - Cable cutsheets
  - Protection documentation

Source: Adapted from IEEE 2800-2022

Components of an IBR Plant – Inverters

Easy in the steady state, much more difficult in dynamic simulation

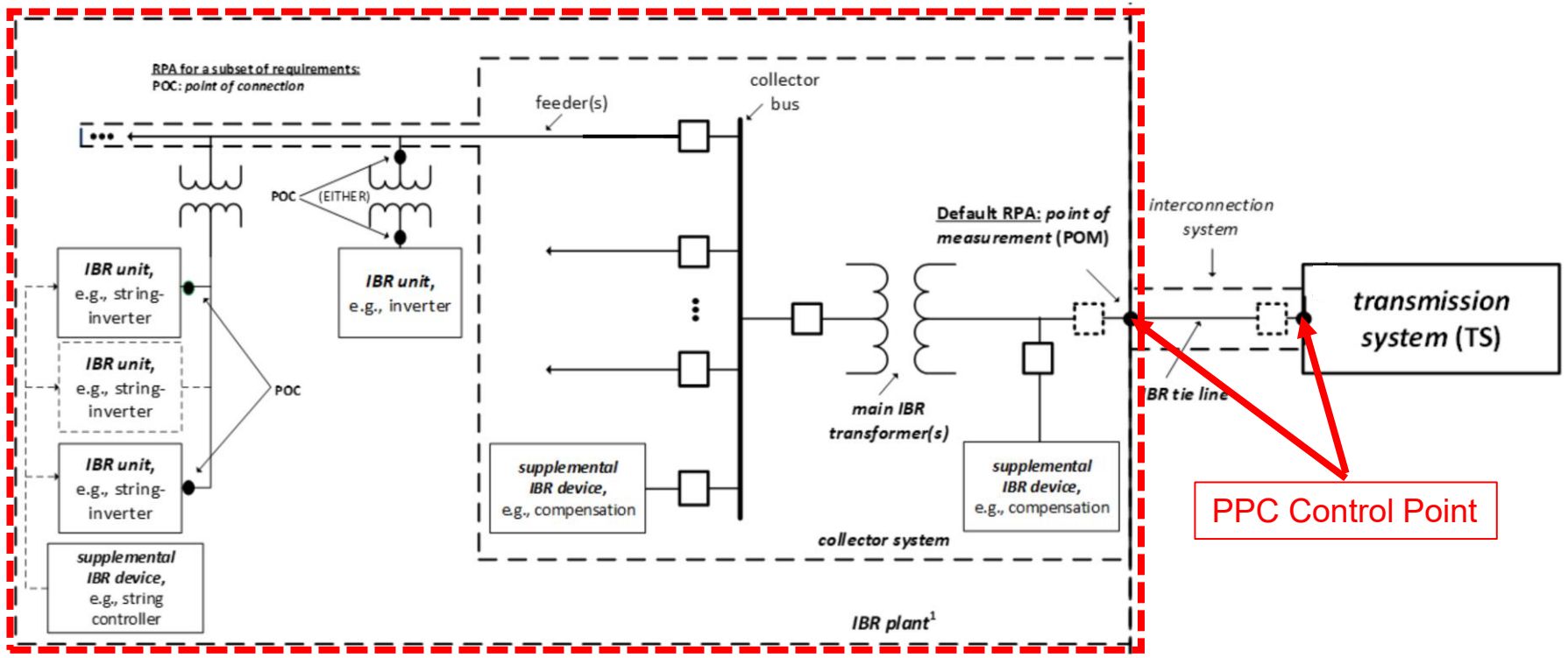


- "Inverter" means OEM provided equipment
  - Could include in inverter model and generator step-up transformer (GSU)
  - Could have this information included in one component and connect directly to collector voltage
- In steady state: inverter models are relatively simple and are comprised of easy to transpose data from the OEM
  - Represent capabilities of the inverter
  - Contain the correct data to link to dynamic models
- In dynamics:
  - Actual performance must be represented based on level of detail and type of study
- Data comes from developer or their OEM
  - Inverter active power capabilities
  - Inverter reactive power capabilities
  - GSU impedance and tap settings

Source: Adapted from IEEE 2800-2022

Components of an IBR Plant – Plant Controller(s)

Power plant controller(s) work to operate the IBR plant during normal operations and coordinate plant-wide performance



- Not included in steady state models
- May be standalone controller or part of multiple PPC control scheme
  - Needs to also coordinate with supplemental devices and MPT controls
  - Difficult to manage multiple OEM and control vendors
- Data comes from developer, Inverter OEM, or their PPC OEM
  - OEM plant controller documentation
  - Third party documentation
  - Communication protocols

Source: Adapted from IEEE 2800-2022