Full Network Model for CRR Allocation

CRR Educational Class #3

CAISO Market Operations

Why is the FNM Important to CRR Allocation?

- The FNM is the underlying cornerstone in the allocation of CRRs
- The FNM along with the operating constraints and contingencies model the transmission capacity that is being allocated
- Shift factors are derived directly from the FNM
- Understanding of the FNM is critical for market participants to effectively request CRR

Course Objectives

- Upon completion of this course, you will be able to:
  - Identify the different components of the full network model, both AC and DC
  - Understand the differences between the AC and DC network models

Agenda

- The Two Types of FNMs
- Components That Comprise the FNMs
- CAISO Network Models
- The Process of Developing the FNMs
- The DC FNM Model for CRR Allocation

Two Types of FNMs

- Alternating Current (AC) FNM
  - Used in the
    - Day-ahead integrated forward market (IFM)
    - Hour-ahead Scheduling Process
    - Real-time energy balancing market
- Direct Current (DC) FNM
  - Used in the CRR allocation process
- Important to understand the differences between the AC and DC FNM

AC FNM

- The FNM attempts to model all details of the actual power system network
- To be used in software programs that
  - Ensure the system is operated in a secure manner in the short term
    - Construction of operating constraints and procedures
  - Ensure that the system is planned in a reliable manner in the longer term
    - New transmission facilities
    - New generation interconnections

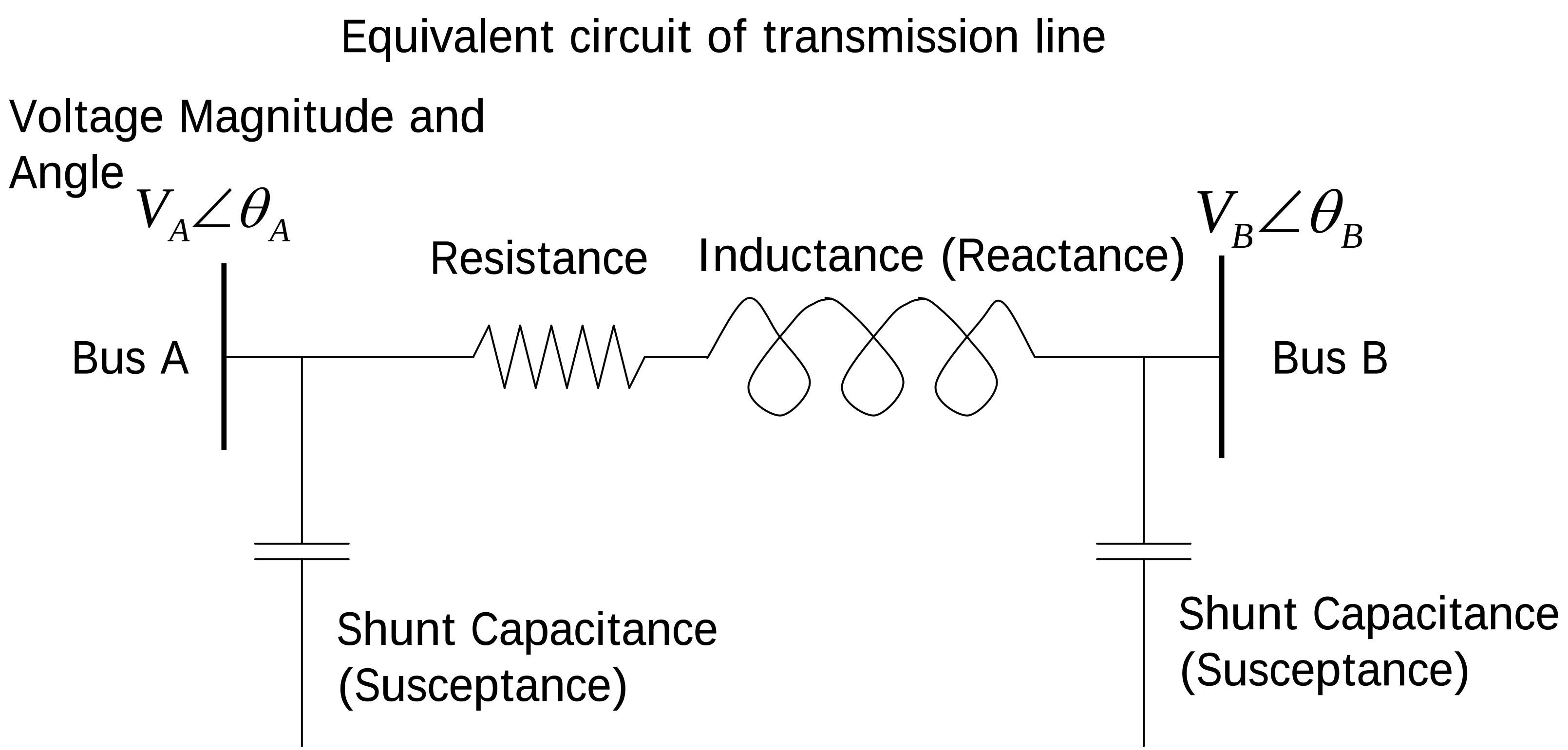
Agenda

- The Two Types of FNMs
- Components That Comprise the FNMs
- CAISO Network Models
- The Process of Developing the FNMs
- The DC FNM Model for CRR Allocation

AC Power System FNM Components

- Transmission lines
  - Resistance
    - produces transmission losses
  - Inductance
    - Created by magnet field due to alternating current
    - Produces phase difference between voltage and current
  - Capacitance
    - Creating by electrical field due to alternating current
    - Produces phase difference between voltage and current

AC FNM Components



AC FNM Components

- Transformers (changing the voltage level)
- Shunt devices (regulating the voltage)
  - Capacitor banks
  - Synchronous condensers
  - Others

AC FNM Components

- Substations or switchyards
  - Modeled as buses (bus also referred to as node)
- Loads (active power (MW) and reactive power (MVar))
- Generators
- High Voltage Direct Current lines and converters
- Flexible AC Transmission Systems (FACTS) devices
- Others
- Phase Shifting transformers

Agenda

- The Two Types of FNMs
- Components That Comprise the FNMs
- CAISO Network Models
- The Process of Developing the FNMs
- The DC FNM Model for CRR Allocation

CAISO Network Model

- CAISO maintains networks model (or base cases) for control area facilities
- CAISO makes changes/updates to facilities within the CAISO control area in conjunction with the PTOs
- Also checks/compares with network models that the CAISO receives from the WECC

CAISO Network Model

- CAISO model
  - AC transmission model
  - 60 kV to 500 kV components modeled
  - Bus/Branch model
  - General Electric PSLF format
  - Does not provide details of bus sections and the breakers that connect the bus sections
  - Includes the whole WECC transmission system

CAISO Network Model (continued)

- Statistics
  - The WECC model
    - ~ 14,000 buses
    - ~ 18,000 lines
  - CAISO control area
    - ~ 4,000 buses in CAISO control area
    - ~ 6,000 lines in CAISO control area

Different Network Models

- Network models generally represent the following seasons/time-of-use periods
- Seasons
  - Spring
  - Summer (may also have summer super peak)
  - Autumn
  - Winter
- Time-of-use (TOU)
  - On-peak (heavy load conditions)
  - Off-peak (light load conditions)

Difference in Network Models

- Differences between the seasonal/TOU network model include
  - Generation patterns
  - Line switching
  - Active (MW) Load pattern
  - Reactive (MVar) Load pattern
  - Line ratings
  - Planned line and generation outages

Network Models Historically Used at the CAISO

- Operations Engineering Department Network Models
  - Analyze the system for a period up to 1 year in the future
  - Analyze proposed clearance (outage facilities) conditions
  - Make sure the day-to-day operating procedures are up to date
- Transmission Planning Department Network Models
  - Analyze the system for a period of 1 year to 10 years out for planning purposes
  - Studies for generation interconnection
  - Studies for upgraded/new transmission facilities
  - RMR studies

Agenda

- The Two Types of FNMs
- Components That Comprise the FNMs
- CAISO Network Models
- The Process of Developing the FNMs
- The DC FNM Model for CRR Allocation

Process of Developing Full Network Model

- The development of the FNM for both IFM and CRR allocation is a multi-step process
- Start with a CAISO maintained network model
- This model is then transformed into the Common Information Model (CIM) format
  - All detailed bus information is added for all buses within CAISO control area
  - Add in bus section details
  - This model is now a bus/breaker model
    - Detailed CIM

Process of Developing Full Network Model

- Integrated Forward Market
  - From detailed CIM
  - Default breaker statuses applied
  - Topology process creates an AC bus/branch model
  - Known or Scheduled outages are also applied

Process of Developing Full Network Model

- CRR
  - From detailed CIM
  - Annual CRR allocation/auction model
    - Assumes all lines in service unless major sustained outages
    - Do not want to allocate/auction capacity that will not be there
  - Monthly CRR allocation/auction model
    - Selected planned/scheduled outages are applied
    - Do not want to allocate/auction capacity that will not be there
  - Topology process creates an AC bus/branch model
  - AC bus/branch is input into CRR system
  - CRR system converts the AC model to DC model

Agenda

- The Two Types of FNMs
- Components That Comprise the FNMs
- CAISO Network Models
- The Process of Developing the FNMs
- The DC FNM Model for CRR Allocation

DC FNM Used for CRR Allocation

- The DC model is an approximation of the AC model
- Referred to as “Direct Current” network model
- Analysis on this network is linear and resembles analysis on a direct current (not alternating current) network
  - A direct current network is a network with only resistances and constant (not alternating) voltage sources
  - This type of network is linear

DC Network Model Assumptions

- Resistance much smaller than reactance
- Voltage Magnitudes are always near rated kV
- Reactive load much smaller relative to active load
- Reactive flow on lines much smaller relative to active flow on lines

DC Network Model

- DC model derivation for the CRR allocation/auction
  - Start with an AC system
  - Set all resistances to 0.0
    - There are no losses
  - Set all voltages to 1.0 per-unit
  - Remove all loads, generators and any shunt devices

Passive DC Network Model

- Conversion from AC to DC for CRR allocation
  - Results in a *Passive* network model
    - No generation
    - No load
  - The Sources from the CRRs that are applied act like generation/imports
  - The Sinks from the CRRs that are applied act like load/exports

Why Use the DC Network Model?

- AC system of equations are nonlinear
- DC model does not model losses
  - No losses
  - Source injections equal Sink withdrawals
  - CRRs do not hedge against losses so loss modeling is not needed
- DC system of equations are linear
  - A linear system is much easier to work with as compared to nonlinear
  - Can use the properties of superposition
- Constraints that are used in the AC system can be modified (e.g., scaled) to be effectively used with a DC model

Why Use the DC Network Model?

- Forward market uses AC model so that forward schedules are feasible with respect to real-time
- CRRs are a financial instrument
  - CRRs are not involved in the Forward or real-time markets
  - Allocating financial rights
  - Financial hedge includes only congestion price difference and does not include transmission loss component

Any Questions?