Classification of
Bulk Power System Elements

Adopted by the Members of the Northeast Power Coordinating Council Inc., this April 28, 2007 based on recommendation by the Reliability Coordinating Committee, in accordance with Section VIII of the NPCC Inc. Bylaws dated May 18, 2006 as amended to date.
1.0 Introduction

NPCC defines specific requirements applicable to design, operation, and protection of the bulk power system. The object of this Classification of Bulk Power System Elements (Document A-10) is to provide the methodology to identify the bulk power system elements, or parts thereof, of the interconnected NPCC Region.

The methodology in this document is used to classify elements of the bulk power system and may result in elements being added to or removed from the NPCC Bulk Power System List. The methodology in this document is based on the following:

- Results of an analysis done on a bus basis can be applied to identify which elements, or portions thereof, connected to the bus are part of the bulk power system.

- Elements shall not automatically be included or excluded from the bulk power system based on voltage class. Application of this methodology may be omitted at buses that can be logically excluded from the bulk power system based on study results at other buses tested using this methodology. If a bus is determined to be bulk power system, all other buses with elements connected to that bus must be tested.

- Elements shall be evaluated based on this methodology when significant changes occur on the system that could change an element’s bulk power system status; the evaluation may be limited to the affected part of the system.

- Areas and facility owners may adopt methodologies that exceed the requirements set forth in this document for their own purposes. However, only elements classified as bulk power system as a result of testing described in this document shall be included on the NPCC’s list of bulk power system elements. NPCC criteria and compliance monitoring shall consider only the system elements listed on NPCC’s list of bulk power system elements.

The Classification of Bulk Power System Elements is based on three defined terms: bulk power system, local area and significant adverse impact.

2.0 Definitions
2.1 Bus

Within this document the term *bus* refers to a junction with sensing or protection equipment within a substation or switching station at which the terminals of two or more elements are connected, regardless of whether circuit breakers are provided. In this context, *bus* may not have a direct correlation to the use of this term in substation design or a power flow data set.

In some configurations a *bus* may include more than one physical *bus*, such as in a breaker-and-a-half arrangement or a single-line-single-breaker arrangement in which two physical *buses* are connected through a *bus*-tie breaker. The examples in Figure 1 depict two of many possible configurations where two physical *buses* are tested as a single *bus*. *Buses* that are separated by normally open *bus*-tie breakers are considered as separate *buses*. The termination of line sections through switches should not be considered as a *bus* requiring testing unless the switches are activated as part of a protection system for the line which they sectionalize as part of normal protection system actions.

![Figure 1 – Configurations where Bus A and Bus B are tested as one bus.](image)

In some configurations elements may not be terminated to the *bus* through circuit breakers, such as the generator *bus* for a unit connected generator or a *bus* between a transmission line and transformer that are switched as a single circuit. The examples in Figure 2 depict two of many configurations where two physical *buses* are tested as separate *buses*. 
2.2 Uncleared Locally

Within this document the phrase *uncleared locally* is used to denote failure of the *protection* including *Special Protection Systems* for the *bus* under test to initiate tripping of all associated interrupting devices regardless of their location.

*Protection* located at other *buses* is assumed to operate as designed when that *protection* cannot be disabled by failure of a single component in common with the *protection* at the *bus* under test. For example, consider the case where the *protection* for *elements* connected to higher voltage level and lower voltage level *buses* in the same station share a dc source, and an independent dc source is provided for second *protection groups* associated with *elements* connected to the higher voltage level *bus*. In this case, it is acceptable when testing the lower voltage level *bus* to assume correct operation of any *protection groups* associated with *elements* connected to the higher voltage level *bus* capable of detecting the *fault* and supplied by the independent dc source.

In cases where circuit breakers are not provided at the terminals of the *element* at the *bus* under test (as shown in Figure 2, *bus A*), *uncleared locally* includes a failure to clear a *fault* by circuit breakers located at another *bus* within the same substation, unless back-up *protection* at that other *bus* using an independent dc source would detect the *fault* and initiate clearing.

3.0 Classification of Bulk Power System Elements

3.1 Testing Conditions and Assumptions

Studies conducted for the purpose of determining the *elements* of the *bulk power system* shall assume the following conditions:
3.1.1. Power flow transfers, load and generation patterns expected to exist for the period under study which stress the system in a manner critical to the classification of the bus to be tested. All reclosing facilities rendered inoperative.

3.1.2. Operation of Special Protection Systems, undervoltage load shedding and underfrequency load shedding modeled as designed.

3.1.3. Load models used in the Transient Stability Test are consistent with Area practices for the studies of rotor angle stability.

3.1.4. Load models used for steady state testing are either constant MVA or are based on actual system testing with LTC movement.

3.1.5. Stability simulation runs until the system response can be clearly determined.

3.1.6. Generic or detailed relay models to monitor, after tripping of remote terminals, the potential for tripping of un-faulted elements.

3.2 Test Methodology

Both transient stability and steady-state tests are used to determine the impact on system performance resulting from power system faults.

Testing is based on application of a bus fault at a single voltage level that is uncleared locally. Tripping of un-faulted elements associated with clearing the test fault does not constitute a significant adverse impact.

Depending on system configuration or topology, testing only faults at buses can fail to uncover significant adverse impacts arising from a design criteria contingency involving the loss of two adjacent transmission circuits on a common tower. Hence, specific tests in 1c and 2c below are designed to assess this contingency for its potential significant adverse impact outside of the local area.

A transient stability test may be done first to identify buses at which faults may cause a significant adverse impact outside of the local area.

For those buses which are not classified as bulk power system in the transient stability test, a steady-state test is used to identify buses at which faults may cause a significant adverse impact outside of the local area.
Step 1 - Transient Stability Test

Simulate the transient stability condition of a three-phase fault with delayed clearing at the bus under test (step 1a). If the test results in a positive bulk power system determination, more detailed testing (step 1b) may be applied to obtain a more precise determination.

1a. Apply a three-phase fault for at least 10 seconds at the bus that is being tested. Do not open any of the elements connected to the bus for the duration of the fault. After 10 seconds, simulate tripping of all terminals of each element connected to the bus under test. In cases where there is no fault interrupting device at the remote terminal of an element, open all terminals of all elements between the bus under test and the interrupting device(s) that will open to clear the fault. This test is performed as an efficient, but conservative method for evaluating the impacts of:

- bus faults which would result in faster clearing time, and
- faults off the bus.

It is recognized that due to the conservative nature of this test some elements could be classified unnecessarily as part of the bulk power system. If the above test results in a positive bulk power system determination, the following additional testing may be utilized to obtain a more precise determination. Subsequent testing utilizes design clearing times for the conditions being tested, as stated below.

1b. Apply a three-phase fault at the bus, which is uncleared locally and trip the remote terminals of all elements that will open to clear the fault. Remote clearing times shall be based on design fault clearing times, assuming no communications from the station under test to the remote terminals.

Transformers and other elements connected to the bus shall only be tripped by operation of independent remote protection groups capable of clearing a fault on the bus under test.

Some protection groups (e.g. directional comparison blocking) at remote terminals may provide high-speed fault clearing for faults at the bus under test. In order to test the effects of longer fault clearing times for fault conditions when these remote protection
groups would not provide high speed fault clearing, for either test (1a) or (1b) above:

- High-speed fault clearing at remote terminals must be ignored; or
- Testing must vary the placement of the 3-phase fault on the elements connected to the bus under test to include locations beyond the reach of the high-speed tripping relay element at the remote terminal.

However, the protective relay settings may be reviewed to determine whether the bus could be classified as not part of the bulk power system if faster remote fault clearing can be achieved. If protective relay settings are modified, an assessment shall be conducted to ensure that the faster clearing time does not compromise the security of the protection system. Until the protective relay settings are modified, the bus must be classified as bulk power system.

1c. The test above is meant to cover the majority of design criteria contingencies. However, the elements associated with the bus under test must be reviewed to ensure adverse consequences resulting from a design criteria contingency involving the loss of two adjacent transmission circuits on a common tower are not overlooked.

If a circuit terminating at the bus under test shares a multiple circuit tower with an adjacent circuit that does not terminate at the bus under test, the adjacent circuit design contingency must also be assessed. In such cases, simultaneous permanent phase to ground faults on different phases of each of two adjacent transmission circuits shall be applied at critical common tower locations. The fault on the circuit associated with the bus under test which is uncleared locally, shall be simulated with normal fault clearing at the remote terminal and on the adjacent circuit.

If the fault has a significant adverse impact outside of the local area, the bus is classified as part of the bulk power system.

For buses not classified as part of bulk power system in Step 1, continue with the Steady State Test in step 2.

**Step 2 - Steady State Test**

Simulate the post-contingency steady-state conditions based on one of the
following outcomes of the fault applied to the bus under test:

2a. If the fault was cleared based on design fault clearing times in the Transient Stability Test, open the same elements that were opened to clear the fault in the Transient Test. Post-contingency conditions shall reflect operation of all automatic devices.

2b. If the fault was not cleared based on design fault clearing times in the Transient Stability Test, assume that the fault propagates to the nearest location where it can be detected by independent protection groups and open the elements that would be opened by the protection groups to clear the fault. Note that because fault clearing will occur at interrupting devices capable of clearing the fault, it may be necessary to open multiple elements between the bus under test and the relevant interrupting devices, for example, a transmission line and transformer in series as shown in Figure 2.

2c. As in Step 1, the steady state test above is meant to cover the majority of design criteria contingencies. However, the elements associated with the bus under test must be reviewed to ensure adverse consequences resulting from a design criteria contingency involving the loss of two adjacent transmission circuits on a common tower are not overlooked. The post-contingency analysis must assess the loss of any adjacent circuit on common towers with a circuit terminating at the bus under test in addition to the elements associated with the bus under test.

Voltages and thermal loading will be assessed for significant adverse impact outside of the local area following automatic actions. In cases where a power flow solution is not obtained, other techniques shall be used to assess the impact of the event on the power system.

If the fault has a significant adverse impact outside of the local area, the bus is classified as part of the bulk power system.

Note that Step 2 can be done prior to Step 1. If a bus is classified as part of the bulk power system by the Steady State Test (Step 2), the Transient Stability Test (Step 1) need not be done for that bus.

3.3 Utilization of Test Results to Classify on an Element-by-Element Basis.

Classification of bulk power system elements is achieved by applying the results of the above tests to the elements connected to the tested bus.
An element with only one terminal such as a generator, shunt reactor, or capacitor bank, is classified as part of the bulk power system if the bus at which it is connected is classified as part of the bulk power system.

An element with multiple terminals such as a transformer or transmission line is classified as part of the bulk power system if any terminal of the element is connected to a bus that is classified as part of the bulk power system. The bulk power system classification may be limited to only a portion of the element if all of the following conditions are met:

- At least one terminal is connected to a bus that is not part of the bulk power system.
- The Steady State Test has been applied at the buses connected to all terminals of the element and none of these buses have been classified as part of the bulk power system based on results of the Steady State Test.
- The Transient Stability Test has been applied between the terminals of the element to identify those portions of the element for which the Transient Stability Test will not result in a significant adverse impact outside of the local area.

3.4 **Documentation**

Documentation for Bulk Power System classification shall include:

- 3.4.1 The rationale for the test conditions and assumptions used that are not listed above in 3.1.
- 3.4.2 The criteria used in evaluating the result of the testing including but not limited to stability, voltage, and thermal performance.
- 3.4.3 Detailed result of the testing shall be provided upon request.

4.0 **Application and List Maintenance**

Each Area shall be responsible for the application of the Classification of Bulk Power System Elements as described in this document and shall submit proposed changes and supporting documentation to the Task Force on System Studies (TFSS).
The “NPCC Bulk Power System List” will be maintained by the TFSS. Additions to and removals from the NPCC Bulk Power System List will be submitted by TFSS to the Reliability Coordinating Committee (RCC) for approval.

4.1 Addition of Elements to the Bulk Power System List

When application of this methodology identifies an element that was not part of the bulk power system should be classified as a bulk power system element, documentation of the analysis shall be presented to the TFSS. Once classification of the element is recommended by TFSS and approved by the RCC the element will be added to the NPCC Bulk Power System List with the appropriate comments and information. All task forces and the Compliance Committee will be notified once an element is approved by the RCC to be added to the Bulk Power System List. Within three months of an element being added to the Bulk Power System List, a plan and schedule for achieving compliance shall be provided to TFSP for review and acceptance. TFSP may require modifications to the proposed plan and schedule.

4.2 Removal of Elements from the Bulk Power System List

When application of this methodology identifies a bulk power system element that no longer should be classified as a bulk power system element, documentation of the analysis shall be submitted to the TFSS. If reclassification of the element is recommended by TFSS and approved by the RCC, the element will be removed from the NPCC Bulk Power System List.

Lead Task Force: Task Force on Coordination of Planning
Reviewed for concurrence by: TFSS, TFCO, TFSP, and TFIST
Review frequency: 4 years
References: Basic Criteria for Design and Operation of Interconnected Power Systems (Document A-2)
NPCC Glossary of Terms (Document A-7)