Transmission Planning Technical Guide

Appendix G

Reference Document for Base Modeling of Transmission System Elements in New England

System Planning
December 6, 2013

Reference Document for Base Modeling of Transmission System Elements in New England

This document provides information on the operating characteristics of transmission system elements, such as Phase Shifting Transformers (PST), located throughout the ISO New England control area. It serves to provide the planning engineer guidance and consistency in modeling these devices in general system studies. This document provides general operation and treatment of such devices in system simulations; however, it may not describe all operating states. Additionally, other studies may suggest revised operating guidelines deemed necessary for expected system conditions.

Phase Shifter Operation

New Hampshire

Saco Valley / Y138 Phase Shifter (1):

This phase shifter is set to permit up to 185 MW of flow onto to the CMP Section 214 (Kimball Road – Saco Valley) 115 kV Transmissions line. The Saco Valley phase shifter is normally operated in automatic power flow control with a defined MW set-point and bandwidth that will maintain this range. The Saco Valley PST can also be operated in manual mode.

Based on operating studies of seasonal load scenarios and line outage conditions, the following recommendations are provided on the operation of the Saco Valley PST and Saco Valley area transmission system.

1. To avoid thermal and voltage constraints, the recommended operating levels for Maine exports on the Saco Valley PST is 50 MW with a bandwidth of plus or minus 25 MW. Operating the Saco Valley PST near 50 MW is also the optimal setting based on minimizing system losses. The maximum acceptable flow from Saco Valley to White Lake on the Y138 line is 100 MW. The maximum acceptable flow from White Lake to Saco Valley on the Y138 line is 50 MW. For the NH and ME area studies, the maximum acceptable flows should be considered.

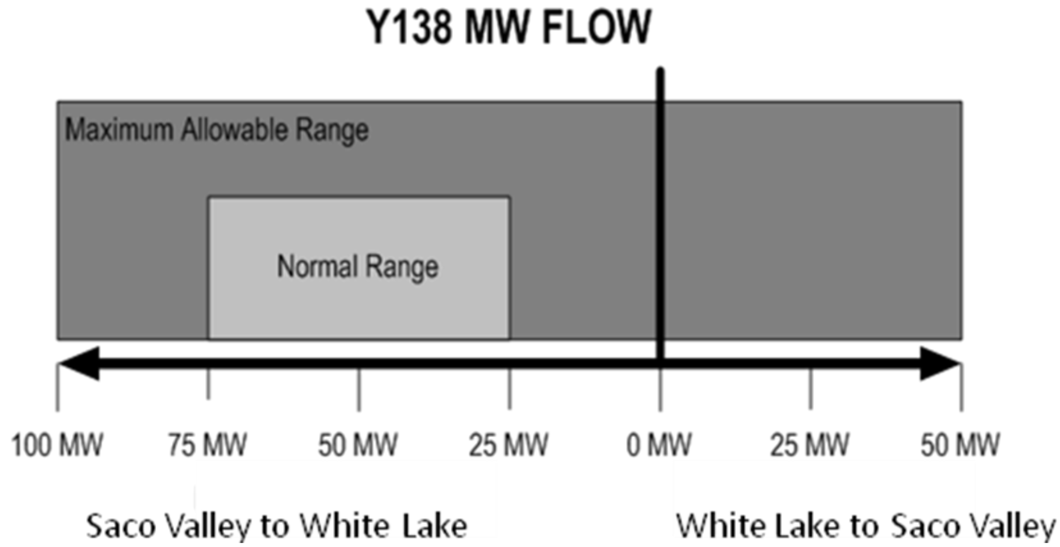
2. The voltage-load tap control setpoint on the Saco Valley PST is recommended to be supervisory manual control on the nominal tap and with a 117 kV plus or minus 2 kV for automatic;

3. The 115 kV capacitor banks at Beebe and White Lake are to be dispatch based on holding the voltage as shown below;

   Beebe 117 kV ±2kV
   White Lake 117 kV ±2kV

There is no preferred sequence for switching capacitor banks at either Beebe or White Lake S/S. However, automatic high-voltage setting is 123 kV and the low-voltage setting is 110 kV with a 30 sec time delay at White Lake and 45 sec time delay at Beebe.

Power Flow Treatment:
Pre-Contingency: Allow to move
Post-Contingency: Locked
Bus Numbers, Circuit ID: 104319, 104330, 1



Vermont

Sandbar Phase Shifter (1)

This phase shifter is set to bring about 100-110 MW from NY to VT, across the PV-20 Plattsburgh-Sand Bar 115 kV line, and supplies power into the northwest Vermont load pocket. The normal operating range is set with flow setpoints of 70 MW (low) and 140 MW (high) into Vermont. The Sand Bar phase shifter has automatic phase shifting control always engaged in a normal system state. The control will take action within 5 minutes of the flow deviating outside of the low and high flow setpoints. VELCO operators will also get alarms when the flow is out of range and will usually act before the 5-minute time delay to adjust the flow on the PV-20 line. In a post-contingency scenario, the automatic flow control is still active, but if a large post-contingency flow is experienced on the Sand Bar phase shifter, the operator assesses the situation and may disable the automatic flow control. For example, if the 340 line is lost when heavily loaded, and the phase shifter is allowed to return to its pre-contingency set flow range, overloads could appear on other VT or NE lines. VELCO's operators have been instructed to disable automatic phase shifter flow control immediately following such an event. Power flow simulations in New England should allow automatic adjustment pre-contingency and assume manual adjustment post-contingency (i.e. locked phase angle).

These guidelines are premised on northern NY conditions that allow these flows. System conditions in northern NY may not allow these flow levels on PV20. Existing system concerns in the Plattsburg area may limit the pre-contingency flow to 0 MW. Depending upon the evaluation being conducted, consideration may also need to be given to this condition to ensure that all relevant system conditions have been evaluated.

Power Flow Treatment:
Pre-Contingency: Allow to move
Post-Contingency: Locked
Bus Numbers, Circuit ID: 107420, 107410, 1

Blissville Phase Shifter (1):

In most cases, this phase shifter is set to send 0 MW to NY from VT and prevents overloads on the NY side of the tie with low and high flow setpoints of 25 MW into NY and 25 MW into VT. However, when the flow on the 340 line (VY-Coolidge 345 kV) is above 350 MW or the Vermont load level is above 930 MW, the operator will set the phase shifter to send 25 MW +/-25MW into NY with a low flow setpoint of 0 MW into NY and a high flow setpoint of 50 MW into NY as measured at Blissville. The Blissville phase shifter has automatic phase shifting control always engaged in a normal system state. The control will take action within 5 minutes of the flow deviating from the low and high set points. VELCO operators will also get alarms when the flow is outside of the flow setpoints and will usually act before the 5-minute period to adjust the flow on these ties. In a post-contingency scenario, the automatic flow control is still active, but if large post-contingency flows show up on the Blissville phase shifter, the operator assesses the situation and will disable the automatic flow control if necessary. For example, if the 340 line is lost when heavily loaded, and the phase shifter is allowed to return to its pre-contingency set flow range, overloads could appear on other VT or NE lines. VELCO's operators have been instructed to disable automatic phase shifter flow control for such an event. Power flow simulations in New England should allow automatic adjustment pre-contingency and assume manual adjustment post-contingency (i.e. locked phase angle).

Power Flow Treatment:
Pre-Contingency: Allow to move
Post-Contingency: Locked
Bus Numbers, Circuit ID: 107750, 107740, 1

Granite Phase Shifters (2):

In most cases, the two phase shifters at Granite are locked in neutral (0 degrees). The Granite phase shifters can be operated automatically, but are currently locked at some angle both pre and post contingency (assumed to be 0 degrees). If there's a need to increase the flow on the F-206 line, the phase shifters would be reverted back to automatic operation pre-contingency and operators would disable automatic operation post-contingency if large flows show up across the phase shifters. For example, if the Highgate converter is out of service and the Vermont load is high, it is likely that the flow on the 340 line (a proxy for high Vermont import) will also be high. Loss of the 340 line, under these conditions, may cause severe thermal and voltage violations. Adjusting the Granite phase shifters to import up to 250 MW into Vermont will minimize the system concerns. The amount that can be allowed to flow on the F-206 line depends on the amount of generation running on the 230 kV system at Comerford, Moore, or AES Granite Ridge. The Comerford and Moore units are more effective at preventing overloads on the New Hampshire 115 kV system. Loss of B-202 is typically the limiting contingency overloading the P-145 line and the A-111 line.

Adjustments of the flow on the F-206 line with the Granite phase shifters may require adjustment of the reactive resources at Granite. The expectation is that at a 0 degree phase angle on the Granite phase shifters, the Granite synchronous condensers should be operating around 0 MVARs, the Granite 115 kV bus voltage should be between 1.01 to 1.03 per unit, and the Granite 230 kV voltage should be between 1.005 to 1.035 pu. This will be accomplished with the tap-changing 230/115 kV transformers controlling the Granite 230 kV voltage and the 115 kV caps at Granite being used to maintain the 115 kV voltage. At higher F-206 flows (where the Granite phase shifters are NOT at 0 degrees), the Granite synchronous condensers would be operated to absorb MVARs pre-contingency to "spring load" the system to react to a low voltage condition. This is accomplished by switching in one or more Granite 115 kV caps.

Power Flow Treatment (if the phase shifters ARE NOT used to control flow into VT):
Pre-Contingency: Locked at 0 degrees phase shift
Post-Contingency: Locked at 0 degrees phase shift
Bus Numbers, Circuit ID: 107580, 107570, 1
Bus Numbers, Circuit ID: 107590, 107570, 1

Power Flow Treatment (if the phase shifters ARE used to control flow into VT):
Pre-Contingency: Allow to move

Post-Contingency: Locked
Bus Numbers, Circuit ID: 107580, 107570, 1
Bus Numbers, Circuit ID: 107590, 107570, 1

Massachusetts - Boston

Waltham Phase Shifters (3) (MANUALLY ADJUSTED):

Three-phase shifters at Waltham are adjusted manually to ensure no contingencies in the Boston area would cause STE violations post-contingency. After a contingency has occurred, these phase shifters are manually adjusted to bring back flows to within LTE ratings.

Pre-Contingency

The correct phase shifter settings are dependent upon a number of variables, such as load level, internal Boston generation, and external flows (e.g. N-S, SEMA/RI, and Phase II). Both the Baker Street and Waltham phase shifters should be pulling in the same direction and are typically set to move power into Boston, with general exceptions being under high generation and light load conditions. In addition, phase shifter tap settings between Baker Street and Waltham should not be more than two tap settings apart (+1, +3).

Power Flow Treatment:
Pre-Contingency: Locked
Post-Contingency: Locked
Bus Numbers, Circuit ID: 110809, 110810, 1
Bus Numbers, Circuit ID: 110809, 110810, 2
Bus Numbers, Circuit ID: 110809, 110810, 3

Baker Street Phase Shifters (2) (MANUALLY ADJUSTED):

Two-phase shifters at Baker Street are adjusted manually to ensure no contingencies in the Boston area would cause STE violations post-contingency. After a contingency has occurred, these phase shifters are manually adjusted to bring back flows to within LTE ratings.

Pre-Contingency

The correct phase shifter settings are dependent upon a number of variables, such as load level, internal Boston generation, and external flows (e.g. N-S, SEMA/RI, and Phase II). Both the Baker Street and Waltham phase shifters should be pulling in the same direction and are typically set to move power into Boston, with general exceptions being under high generation and light load conditions. In addition, phase shifter tap settings between Baker Street and Waltham should not be more than two tap settings apart (+1, +3).

Power Flow Treatment:
Pre-Contingency: Locked
Post-Contingency: Locked
Bus Numbers, Circuit ID: 110888, 110886, 1
Bus Numbers, Circuit ID: 110889, 110887, 1

Connecticut

Sackett Phase Shifter (1)

This phase shifter operates in a non-automatic mode only (manual) and is normally set in the Raise 3 Tap (1.875°) which tends to draw power flow from Grand Ave thru this phase shifter towards Mix Ave substation. Studies show the tap may need adjustment for various reasons including certain post-contingency and planned outage operating conditions to either improve Southern Connecticut transfers or alleviate potential overload conditions. The tap should be returned to the Raise 3 position when the system is returned to the normal configuration.

Power Flow Treatment:
Pre-Contingency: Locked
Post-Contingency: Locked
Bus Numbers, Circuit ID: 123166, 123211, 1

Northport / 1385 Phase Shifter (1):

The Phase Shifter may be used to control the load flow on Norwalk Harbor-Northport 601, 602 and 603 Cables.

The Phase Shifter is equipped for operation by automatic or supervisory control from the Long Island Power Authority (LIPA) System Operating Center and by local control from the Northport Control House. Normally, the control will be automatic. Normally, the loading of Norwalk Harbor-Northport 601, 602 and 603 Cables will be as agreed by ISO-NE System Operator and NYISO Shift Supervisor. In an emergency, the CONVEX System Operations Supervisor may request a change in loading on this line directly to the LIPA System Operator, and then notify the ISO-NE System Operator. Similarly, LIPA System Operator may change the loading on this line and then notify the CONVEX System Operations Supervisor. The Phase Shifter is normally computer controlled, and will respond to changes in flow in the following manner:

- If the actual flow exceeds the scheduled flow by greater than the dead-band entered by the LIPA System Operator (usually +/- 20 MW) and lasts at least one minute, the regulator will change at the rate of one tap a minute. If another Long Island phase shifter is also changing taps, the regulator will change at the rate of one tap every two minutes.
- The phase shifter has a total of 65 taps available through two tap changers, one on the Load-side of the phase shifter and the other on the Source-side of the phase shifter. The two tap changers are operated alternately and are never more than one tap apart.
- At full load and at the extreme taps, Northport can lead Norwalk Harbor by 50.3 degrees or Northport can lag Norwalk Harbor by -65.7 degrees.
- The operator can manually change taps at one tap each 30 seconds.

The change in flow per degree is in the order of 25 MW per tap. Therefore, the flow on the cable may be changed as follows:

- Automatic 25 MW per minute (or two minutes), and
- Manual 50 MW per minute.

There is a one-minute delay before the automatic operation begins.

A change of 50 MW or more on any individual LIPA tie line will cause the Northport Phase Shifter to trip off "Automatic" control. If a 50 MW or greater deviation on the scheduled 601, 602 and 603 Cables flows was the cause, control will not be returned to "Automatic" for the Northport Phase Shifter until both NYISO and ISO-NE agree to that return. The Northport Phase Shifter will not trip off

"Automatic" control for any LIPA tie line deviation of less than 50 MW. Note also that the Northport Phase Shifter will trip off "Automatic" control for a tie line deviation of 50 MW or greater in either direction, in to, or out of, LIPA. Therefore, within 1 minute of a 601, 602 and 603 Cables schedule change of less than 50 MW, the Phase Shifter will begin returning the 601, 602 and 603 Cables flow to the scheduled flow. If returning to schedule is not desired, communication with the LIPA system operator is required, requesting that the Phase Shifter be placed in "Manual" until system adjustments have been completed. If it is anticipated that such support may be required for an emergency, advance arrangements should be made with the LIPA system operator.

Power Flow Treatment:

Pre-Contingency: Allow to move

Post-Contingency: Locked (If there is a potential that changes in flow less than 50 MW or returning to scheduled flow on the 601, 602 and 603 Cables will yield system concerns, the analysis should also consider an evaluation with the PAR being allowed to move. However, such analysis may need to recognize potential operator actions being taken prior to returning to schedule in cases where the flow had changed more than 50 MW.)

Bus Numbers, Circuit ID: 129343, 129344, 1

Revision History

Revision Number	Revision Date	Reason for Revision	Author(s)
0	1/29/10	New Guide on modeling and treatment of PSTs in New England	Brent Oberlin
1	07/19/10	Modification to the control mode and the maximum flows of the Saco Valley / Y138 Phase Shifter	Jinlin Zhang
2	07/26/10	Added power flow bus numbers for each phase shifter	Brent Oberlin
3	08/17/10	Corrections to the voltages at Beebe and White Lake	Jinlin Zhang