Dynamic Recording Devices (DRD) in New England Power Pool

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I. Introduction

The New England Power Pool (NEPOOL) is a voluntary association of electric utilities in New England. It connects to New York on the west with several tie lines and New Brunswick on the east with one 345kV line. It also connects Hydro Quebec through two HVDC systems at Highgate (Vermont) and Sandy Pond (Massachusetts), respectively.

The not-for-profit private corporation, ISO New England is responsible for managing the New England region's electric bulk power generation and transmission systems and administering the region's open access transmission tariff.

ISO New England performs analysis of steady state and transient system performance under both normal and post-contingency states. For simulations of the transient response of the power system, the level of power transfer which exhibit instability or undamped oscillation in the 10-30 second time frame are used to develop limits that are imposed in day-to-day operation. Inaccuracies in these limits can unnecessarily restrict operation of the bulk power market in New England and possibly require expensive transmission upgrades. Measurement of the actual response of the power system during significant disturbance can provide valuable information with which to benchmark simulation models and optimize system capabilities. To gauge the accuracy of these dynamic simulations and improve the modeling quality, New England Power Pool decided to procure and install Dynamic Recording Devices that would provide power system measurement with which to benchmark stability simulations.

Installation of Dynamic Recording Devices also facilitates NEPOOL compliance with the NERC Planning Standard section I.F (standard S1 and S2, Measures M1-M6).

II. History of the DRD project in NEPOOL

Mehta Tech Inc installed the prototype DRD at the Northfield substation in 1991. It has been in operation since then. The Northfield DRD is located in the western part of the New England power system and close to New York. The DRD measures instantaneous voltages and currents at a very high sampling rate and computes the frequency, voltages, active power and reactive power flows on lines and transformers. The DRD sends the recorded data to the master station located at the ISO New England office in Holyoke, Massachusetts.

The Northfield installation was the first of a planned group of recorders NEPOOL recognized would be needed to provide a more complete picture of New England system response. The planned recorder installation sites were chosen based on their ability to provide information in each of the following categories:

- Inter-area response and oscillation
- Transient response
- Load response
- Local response

The first category had the most influence over recorder siting since the primary purpose of the recorders would be to collect data with which to benchmark system response of the inter-area oscillation nature. The opportunity to provide data in the other three categories was of secondary concern. Based on these criteria, the seven other sites chosen in addition to Northfiled were as follows: Long Mountain (Connecticut), Orrington (Maine), Scobie (New Hampshire), Pequonnock (Connecticut), Millbury (Massachusetts), Sherman Road (Rhode Island) and Manchester (Connecticut). These seven additional sites will use Transcan 2000 product offered by Mehta Tech, Inc. Installation at these additional sites began in 2001 with Orrington. Millbury, Long Mountain and Manchester were installed at the beginning of 2002. Pequnnock and Sherman Road are planned for installation in May 2002, and the Scobie is expected in 2003. Figure 1 shows the geographic locations of the Dynamic Recording Devices in NEPOOL.

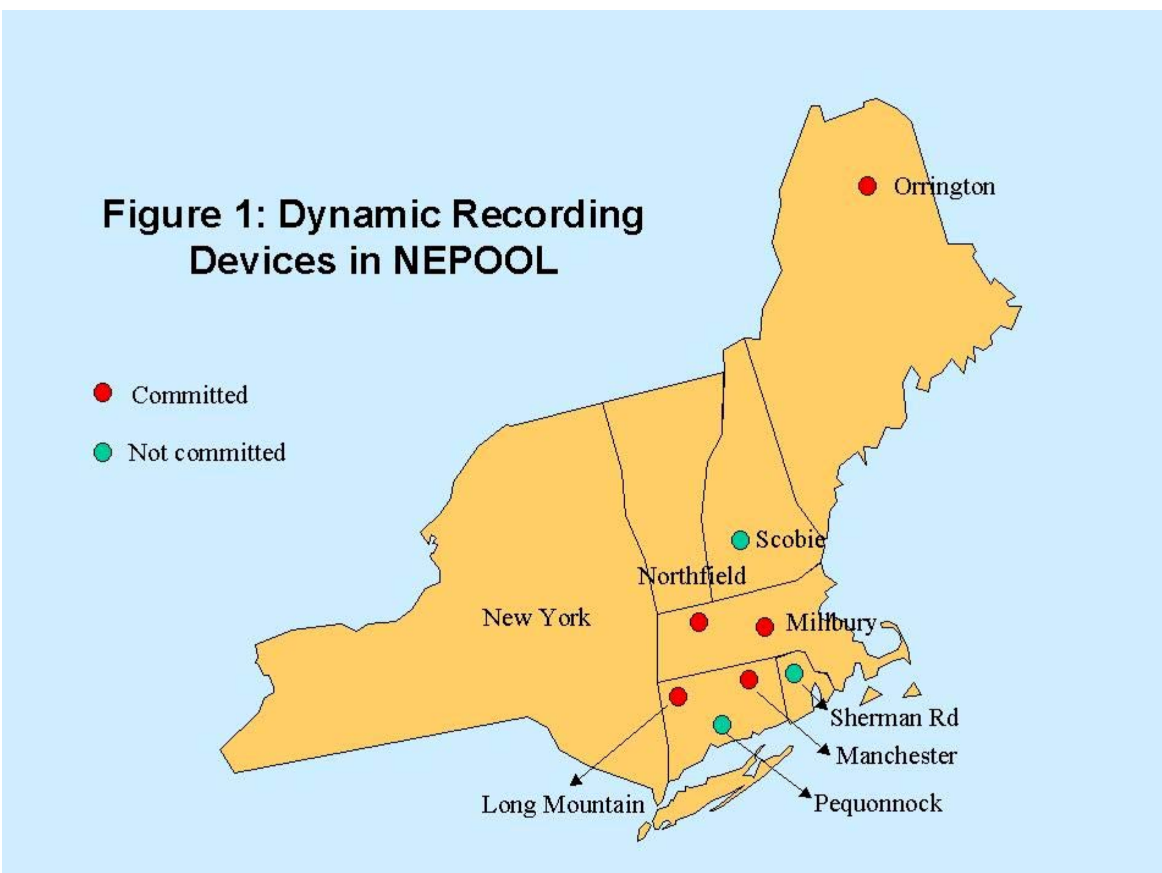

Figure 1: Dynamic Recording Devices in NEPOOL

III. Event Analysis

On Friday, June 1st, 2001, the failure of a current transformer at the Maine Yankee substation caused the Bangor Hydro and Maritimes systems to separate from the rest of the Eastern Interconnection. Following is the sequences of this event.

1) At 12:30:13 hours, a Phase-C-to-ground fault developed on the K392-1 CT column at the Maine Yankee 345 kV substation. The overcurrent relay operated and tripped breakers at Maine Yankee as well as providing a successful transfer trip to breakers at Maxcys causing line 392 (Maxcys-Maine Yankee) to trip.
2) The power that normally flows from Maxcys to Maine Yankee was forced onto the Maxcys 345/115 kV transformer T3, overloading 115 kV section 68 at Maxcys. Section 68 overcurrent relay operated and opened the two low-side breaker of the Maxcys T3 transformer.
3) After the Maxcys transformer tripped, the power that normally flows from Keswick to Orrington on Section 396 was forced onto the Orrington 345/115 kV transformers. It overloaded 115 kV section 65 and 205 and caused their overcurrent relays to operate which tripped Section 86 and 203, the Bucksport Energy plant and the MIS plant.
4) Once Section 86 and 203 tripped, the Bangor Hydro and New Brunswick systems remained connected to each other through Section 396 but were separated from the Eastern Interconnection.

Before the event, New Brunswick was exporting 695MW to New England through Section 396 and the Orrington-South interface was carrying 935MW. After the separation frequency rose in the Bangor Hydro/Maritimes island because of excess generation, causing overfrequency relays to reject 587 MW generation.

The Section 68 overcurrent relay is designed to open the two low-side breakers of the Maxcys 345/115 kV autotransformer if the flow on the Maxcys-Manson (68) 115 kV line exceeds 191 MVA for 0.2 seconds. The Bucksport overcurrent relay is designed to trip Section 86 and 203, Bucksport Energy and MIS plant if both the Section 65 line flow towards Bucksport exceeds 134 MVA and the Section 205 line flow towards Bucksport exceeds 138 MVA simultaneously for 0.2 seconds.

Not long before this event, the time delays of these overcurrent relays were changed from 0.6 seconds to 0.2 seconds because simulations had shown that sustained transient low voltage and possible instability could occur if the time delay were 0.6 seconds. At about the same time as this change was made, the Orrington DRD was installed and it was able to capture this event based on its over-frequency trigger. Several digital fault recorders also captured this event, providing excellent measurement with which to benchmark the power system simulation. This event has provided an excellent opportunity for system engineers to benchmark their simulations with actual measurements.

Figure 2 shows the system diagram of Central Maine Power and Bangor Hydro system. Figure 3 is the plot of the current, frequency and voltage at Orrington 345kV substation recorded from the Orrington DRD.

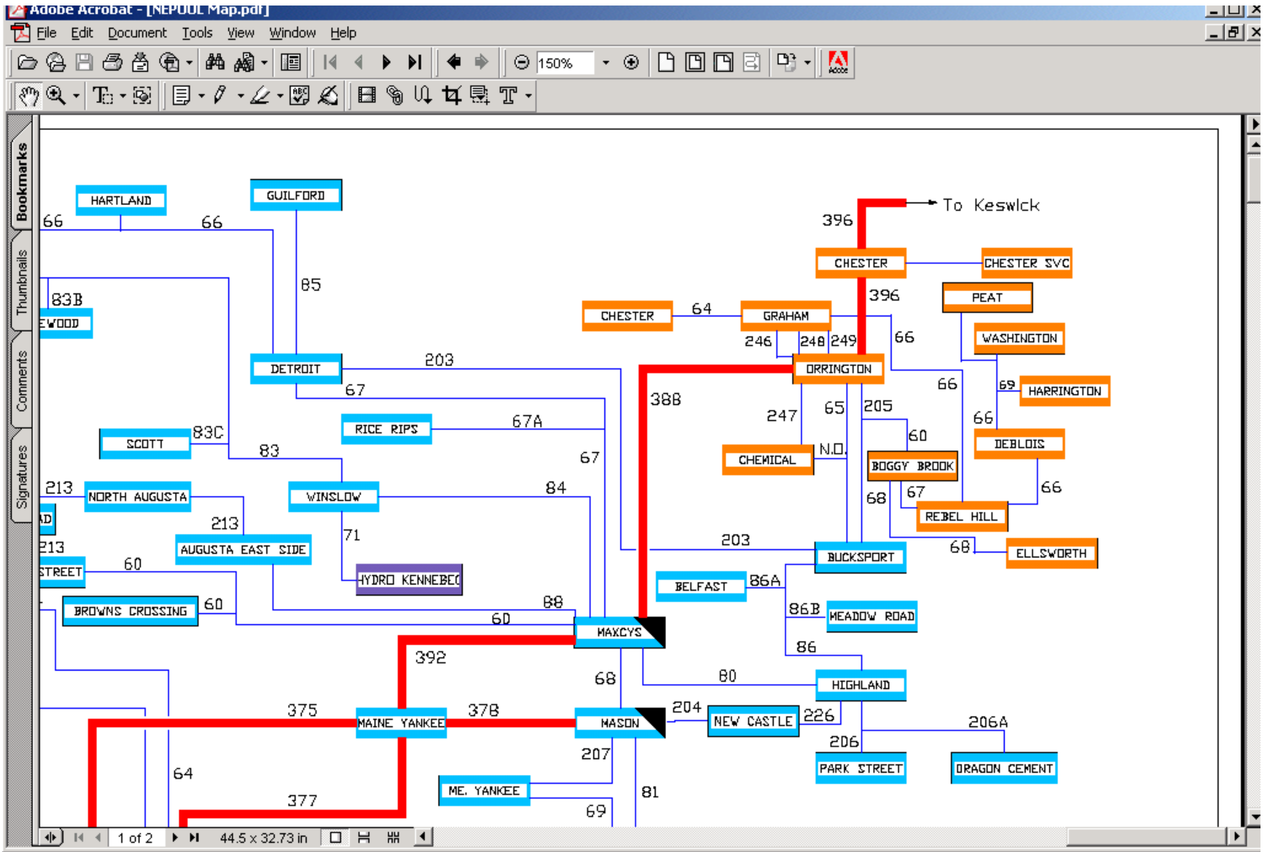

Figure 2: System Diagram of Central Maine Power and Bangor Hydro

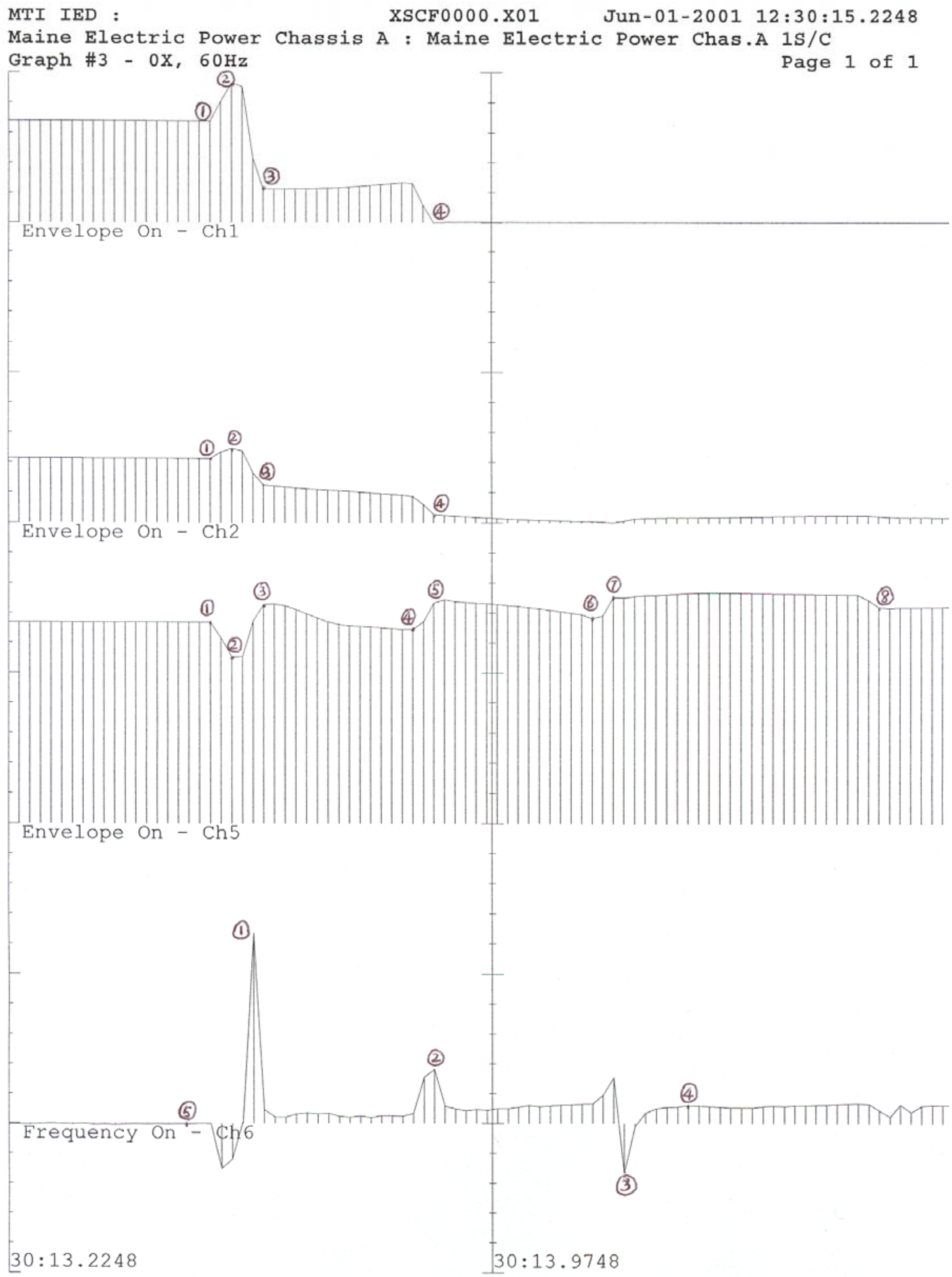

Figure 3: Line Current, Bus Voltage and Frequency at Orrington substation

Channel 1: Current on Line 388 (Orrington –Maxcys)
Point 1: 0ms, 1.541 KA
Point 2: 33.3ms, 1.807 KA
Point 3: 83.3ms, 0.886 KA
Point 4: 350ms, 0.054 KA

Channel 2: Current on Line 396 (Keswick – Orrington)
Point 1: 0ms, 1.156 KA
Point 2: 33.3ms, 1.244 KA
Point 3: 83.3ms, 0.886 KA
Point 4: 350ms, 0.419 KA

Channel 5: Orrington 345kV voltage
Point 1: 0ms, 1.019 p.u.
Point 2: 33.3ms, 0.925 p.u.
Point 3: 83.3ms, 1.064 p.u.
Point 4: 316.7ms, 1.0 p.u.
Point 5: 366.7ms, 1.076 p.u.
Point 6: 600ms, 1.029 p.u.
Point 7: 633.3ms, 1.081 p.u.
Point 8: 1050 ms, 1.058 p.u.

Channel 6: Frequency at Orrington substation
Point 5: 0ms, 60 Hz
Point 1: 66.7ms, 62.85 Hz
Point 2: 350ms, 60.83 Hz
Point 3: 650ms, 59.24 Hz
Point 4: 750ms, 60.28 Hz

IV: Conclusions and Future Developments

Measurement of the actual response of the power system during significant disturbances can provide valuable information with which to benchmark simulation models and optimize system capabilities. New England Power Pool is in the process of installing seven new Dynamic Recording Devices all over the New England, which will provide a more complete picture of the power system response.

In recent years the Northfield recorder has accidentally captured several sustained oscillations. The nature of these oscillations is not well understood. A reliable mechanism for detecting them will provide more insight into these phenomena (i.e.-when and how often the oscillations occur, how long the oscillations persist, their magnitude, etc.) Furthermore, recent simulation studies indicate that, under certain conditions, several large units in New England can create sustained oscillatory conditions.

Currently NEPOOL is working with Mehta Tech Inc to develop an oscillation trigger into the TRANSCAN 2000. The oscillation trigger will be used to capture the inter-area oscillation in the system, with the frequency range of 0.2 Hz to 1 Hz.