Northern Ireland

System Separation Studies

November 2012

Introduction

The purpose of this study was to investigate the rate of change of frequency (ROCOF) occurring on the Northern Ireland system due to system separation, i.e. the loss of the North-South (N-S) tie lines. These studies were carried out as part of an ongoing investigation of the current three machine minimum set rule which is applied in Northern Ireland. The first part of this study was to consider frequency stability under these conditions when the system inertia may be reduced following system separation. This work was also relevant for the DS3 Grid Code working group that are considering Rate of change of frequency (ROCOF) requirements for generators connected to the all-island transmission system.

It should be noted that these studies are based on a system separation event. If Northern Ireland was operating as a separated system i.e. no tie lines in service between Northern Ireland (NI) and Ireland, more onerous ROCOFs may occur and as a consequence different operating rules may apply to mitigate any potential risks.

This report will consider four scenarios. These four scenarios will examine Northern Ireland System ROCOFs for varying imports/exports; varying Wind Farm Power Station (WFPS) production and generation dispatches. In each scenario, system separation results from a 3-phase fault at Tandragee and the subsequent loss of the 275kV tie lines between Louth and Tandragee and the inter-tripping of the 110 kV lines between Enniskillen – Corraclassy and Strabane – Letterkenny. The main objective is to consider system frequency stability and the ROFOF that may result.

This report will present the assumptions used in the studies, the methodology applied, the analysis of results and the conclusions.

Methodology

The case studies will examine the ROCOF that results from the system separation. These studies will **not** consider any short term transient or small signal stability analysis.

The system fault and resulting system separation can have a significant effect on NI frequency stability depending on network conditions. The generation/load imbalance is affected by a number of factors including:

- Commutation failure or blocking of the Moyle interconnector during low voltage conditions
- Loss of Wind Farm Power Station (WFPS) active power production during and after fault clearance, and failure of WFPS commissioned pre 2005 to fault ride through
- Loss of active power import or export on the N-S tie line during and after fault clearance
- Reduced active power output from conventional generators depending on the retained voltage during faults

The dynamic studies were carried out in PSS/E V 30.3.2. In each case a 3-phase fault was placed on the Tandragee 275kV busbar for 120ms then cleared by switching out both 275 kV Tandragee – Louth tie lines. It should also be noted that following the loss of the 275 kV N-S tie lines the 110 kV tie lines, Enniskillen – Corraclassy and Strabane – Letterkenny, are also out of service.

This contingency was studied under four dispatch scenarios, which included high/low system frequency responses after system separation.

The ROCOF results were taken from PSS/E by measuring frequency at major nodes on the NI System. To validate the PSS/E results, the study was repeated in DSA Tools transient stability tool, TSAT. The PSS/E ROCOF values were found to be comparable with the DSA Tools results in the sample investigated.

The ROCOF was calculated from raw 5ms frequency simulation data. The individual ROCOF values were calculated over 100ms time intervals and plotted as a 5 point moving average. Therefore, ROCOF values in this report will be all be measured over a 500ms time period, in alignment with proposed ROCOF definitions.

In each study the additional 400kV N-S tie line is assumed not to be commissioned, i.e. representative of conditions up to 2018/19.

Scenario 1

This study is representative of 2012 system conditions i.e. installed wind capacity, demand and network configuration. The high imports on Moyle and the N-S 275kV tie lines, along with 450MW of WFPS production results in the de-commitment of conventional generating plants in NI and the three “must run” units are dispatched down to min generation levels. The reduced levels of synchronous generating plants on the NI system reduce system inertia and increase the likelihood of frequency transients following system disturbances.

Online Plant	GT8	Synchronous Compensation
	C30	ST – 100MW GT – 160MW
	K1	110MW
	K2	110MW
NI Load		1550MW
ROI Load		4000MW
All Island Load		5550MW
NI Wind		450.9MW
Ireland Wind		1994.5MW
All Island Wind		2445.4MW
Moyle		450MW (Import to NI)
N – S tie lines		260MW (Import to NI)
All Island SNSP		52%

Table 1 - Dispatch for Case Study 1

A 3-phase fault was placed on the Tandragee 275kV busbar for 120ms then cleared by switching out both 275kV Tandragee – Louth tie lines. It should also be noted that on the loss of the 275kV N-S tie lines the 110kV tie lines, Enniskillen – Corraclassy and Strabane – Letterkenny, are also out of service.

The frequency measured during this contingency can be seen in Figure 1.

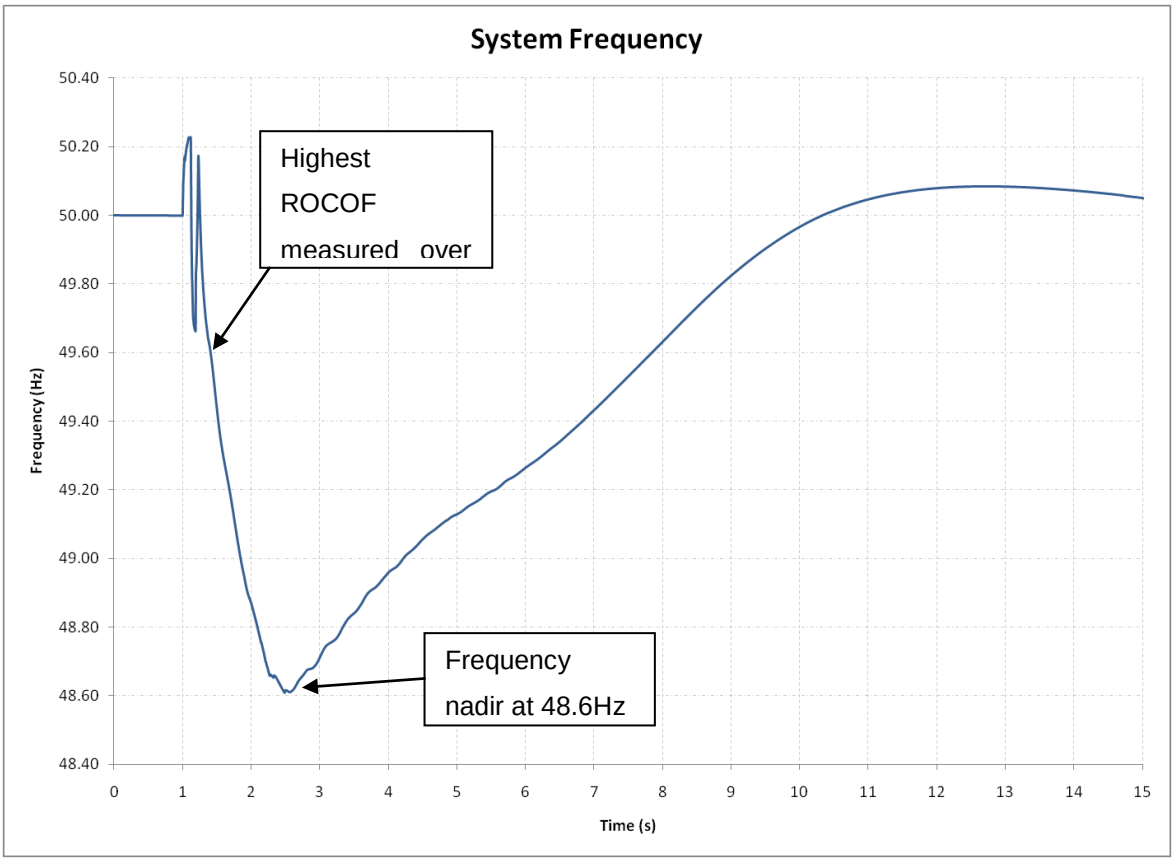

Figure 1 - NI System Frequency during Case Study 1

During the fault the Moyle Interconnector was found to block for circa 120ms and during this time interval 450 MW of generation is removed from the system. In addition, 73 MW of WFPS in NI that was commissioned prior to 2005 tripped due to under voltage protection, and the remaining WFPS entered fault ride through mode. During the fault, the total active power output of the WFPS in NI dropped to 87.2MW, a reduction in output of 363.7MW. The active power output of the WFPS was restored in circa 1 second. The pre-fault import flow on the N-S tie lines was 260 MW, the fault was cleared by tripping the tie lines, and therefore 260 MW of generation was removed from the system.

These generation losses resulted in a large generation/load imbalance and a sudden decrease in system frequency, the highest ROCOF measured over 500ms was 2.1Hz/s. The frequency was restored through a combination of the resumption of the Moyle Interconnector import; the restoration of the WFPS output after fault clearance; and the conventional generators low frequency response and load shedding.

Results

Table 2 below shows the dispatch and ROCOF results of the four scenarios studied. Scenarios 1 and 2 are reflective of current wind levels etc, scenarios 3 and 4 are 2019 cases with wind levels representative of forecasted installed capacity in 2019 and all network upgrades modelled.

	Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**
NI Conventional Plant				
GT8	Synchronous Compensation	Synchronous Compensation	Synchronous Compensation	Synchronous Compensation
C30 – ST (MW) GT (MW)	100 160	0 0	100 160	0 0
K1 (MW)	110	110	110	110
K2 (MW)	110	110	110	110
B10 (MW)	0	65	0	65
Interconnector Flows				
Moyle (MW)	450 (import)	450 (import)	320 (import)	300 (export)
N – S Tie Lines (MW)	260 (import)	260 (import)	260 (import)	280 (export)
Renewables				
NI Wind (MW)	450.9	450.9	800	800
Demand				
NI Load (MW)	1550	1380	1840	520
All Island SNSP (%)	52	54	56	58
ROCOF Results				
Highest value recorded over 100ms (Hz/s)	4.2	8.3	3.1	2.4
Highest value recorded over 500ms (Hz/s)	2.1	3.9	1.8	1.4

Table 2 – Study Results

Conclusions

The ROCOF in Northern Ireland, following system separation, is dependent on a number of related variables, including:

1. System demand
2. The Moyle Interconnector flow (import/export)
3. Northern Ireland generation dispatch (inertia)
4. North – South tie lines flow (import/export)
5. WFPS output

Preliminary system separation studies show, following a fault and system separation, ROCOF figures **in excess of 2Hz/s** in Northern Ireland are possible. It should be noted these studies do not consider the effect of generation disconnection due to other forms of anti-islanding protection, such as vector shift.

SONI will endeavour to operate the system to ensure frequency stability in all scenarios. To achieve this,SONI may have to re-dispatch the generation portfolio; reduce transfers on the N-S tie lines or the Moyle Interconnector flow.

In this context, a RoCoF standard of 2 Hz/s is recommended for Northern Ireland until such time as further system reinforcement is in place between Ireland and Northern Ireland.