Operations Report

Frequency Operating Standard Submission

This document describes the initial Basslink submission to the AEMC Review of Frequency Operating Standards for Tasmania.

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Prepared by	Basslink Pty Ltd

DOCUMENT LOCATION

A soft copy of this document can be found at:
192.168.21.10\Basslink\ HVDC Maintenance\

DISTRIBUTION

Name	Organisation
	AEMC

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1 **Purpose**:

The purpose of this document is to describe the Basslink initial stakeholder submission to the AEMC panel review of the frequency operating standards for Tasmania and request consideration of the factors presented.

2 **Basslink Overview**:

Basslink provided the first electrical interconnection between the Australian state of Victoria and the island state of Tasmania.

Basslink is implemented as a monopolar HVDC interconnector using metallic return with a continuous rating of 500 MW at 400kV DC.

Bass Strait is crossed with submarine cables approximately 295 km in length, with an additional 8 km of underground cable and 66 km of DC overhead line on land.

The Victorian HVDC converter connects to a 3300 MW connection point at a 500kV substation in a strong AC network, while in Tasmania the HVDC converter connects to a 220kV AC system with a maximum generation capacity of approximately 1800 MW.

The interconnector follows power target control from the National Electricity Market Dispatch Engine.

Basslink has a minimum power transfer of 50MW due to the minimum hold on characteristic of the thyristor based converters.

3 HVDC Control Review:

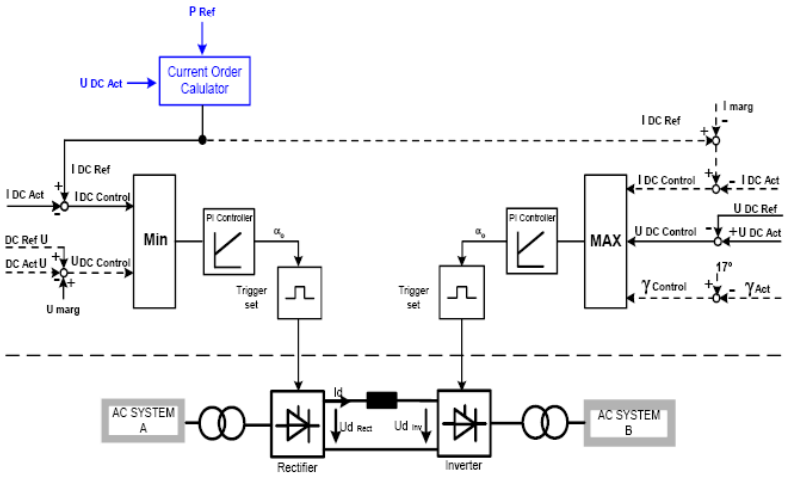

Diagram 1HVDC Converter Basic Control Principle Diagram

Viewing Diagram 1 the HVDC converter control utilises standard feed back error control. A power transfer set point is received and a DC current set point is calculated using actual DC voltage.

The rectifier firing pulses are controlled to maintain DC current, while the inverter firing pulses are controlled to maintain a constant DC voltage.

To improve system response time feed forward is used to compensate the rectifier for DC voltage and compensate the inverter for DC current while the inverter is also compensated for minimum extinction angle.

The converter control can also be utilised for the HVDC link to operate as spinning reserve (frequency control) by additionally compensating the rectifier for frequency deviations.

The Basslink Frequency Controller has a non linear response by design to additionally modulate the power reference to control the system frequencies while considering the different frequency standards of the two systems.

4 Frequency Control Review:

The frequency measurement is based on positive phase sequence filtered values measured from the Converter 220kV / 500kV AC bus and these values are transmitted to the control system every 15 microseconds.

The deviations of each transmission system from 50 Hz is calculated and the frequency control becomes active when the difference between the Tasmanian frequency and the calculated frequency of the Basslink Frequency Controller Objective Function exceeds a dead-band of ± 0.01 Hz and the output of the stability control function modifies the power reference as described in Diagram 2 below.

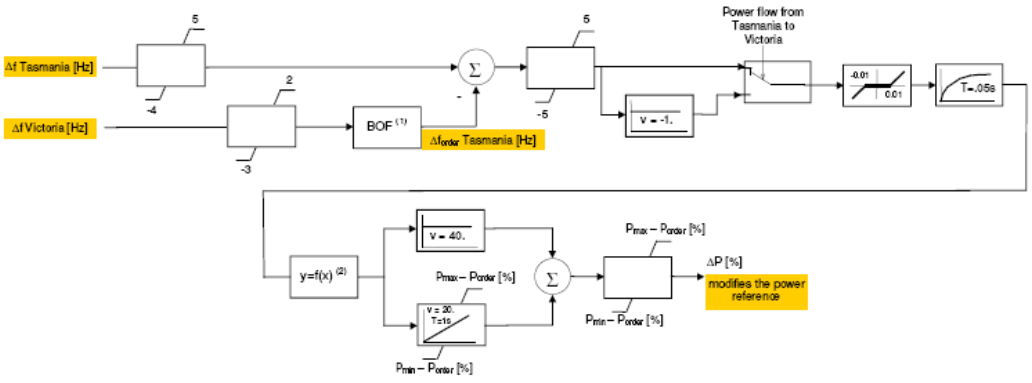

Diagram 2 Frequency Controller Basic Block Diagram

(1) BOF:

Δ f Victoria Hz	-3	-1	-0.5	-0.25	0	0.25	0.5	1	2
Δ F order Tasmania Hz	-4	-2.5	-2.5	-0.25	0	0.25	1	3	5

(2)Non linear gain

x	-10	-0.5	-0.25	0	0.25	0.5	10
y	-10	-0.5	-0.05	0	0.05	0.5	10

$$Basslink\_ObjectiveFunction\_reference = {}^{2}_{-3}(Vic\_Frequency - 50)$$

Frequency Control Error Calculation:

$$Frequency\_control\_error = {}^{5}_{-5}\left[{}^{5}_{-4}(Tas\_Frequency - 50) - (Basslink\_ObjectiveFunction)\right]$$

The frequency control function and all parameters are implemented in software and the values of control parameters determined using a NETOMAC simulation model and PSS/E Stability Model.

5 Frequency Standard Submission:

Basslink welcomes the review of the AEMC panel review of the frequency operating standards for Tasmania and as a stakeholder would like to identify to the Panel the following technical and commercial factors for consideration in the Panel's review of the standards.

5.1 Technical Factors:

Basslink believes that any changes to the standards must consider the capabilities of the Tasmanian system during normal operation and following contingency events.

Any changes to the standard will need to reflect the system frequency changes when the Basslink line commutated current source converter blocks or deblocks firing pulses as this is an instantaneous 50MW load change on the 220kV bus.

The correct source of information on the Tasmanian system capabilities is the National Electricity Market Management Company referencing the high speed data records available, however the following Basslink transient fault recorder traces of system events have been included for consideration as examples.

When a protection operation on the Basslink Interconnector occurs power transfer is reduced, firing pulses are blocked and a Loss of Link signal is issued to the System Protection Scheme to trip load or generation and the line circuit breaker at the converter station that initiates the protection operation is opened.

As the line circuit breaker is opened Basslink transient fault records cannot provide examples of the AC system response following a trip of the Tasmanian converter station.

When exporting from Tasmania Basslink can provide 660MW of assistance to control a positive frequency excursion but can only reduce to the minimum transfer level of 50MW to control a negative frequency excursion providing the AC network parameters are within design criteria reflected in the connection agreement.

When importing to Tasmania Basslink can provide 480MW of assistance to control a negative frequency excursion but can only reduce to the minimum transfer level of 50MW to control a positive frequency excursion providing the AC network parameters are within design criteria reflected in the connection agreement.

5.1.1 Example of Separation Event:

The following is an example of a trip of the Basslink Interconnector initiated from the Victorian converter station, the Tasmanian converter station line circuit breaker remains closed and the transient fault recorder shows the Tasmanian system response to the event.

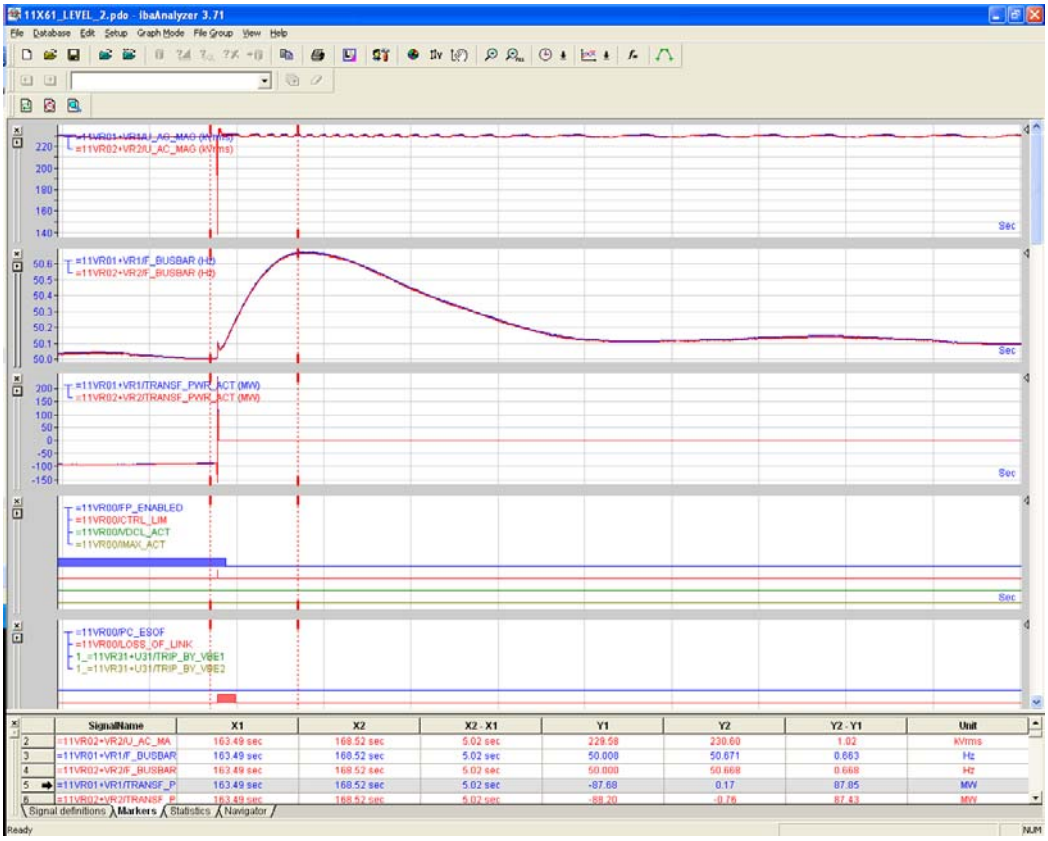

Diagram 3 Basslink Level 2 Transient Fault Record

Viewing Diagram 3 a steady state reference 163.49 seconds from the beginning of the record has been selected showing the interconnector is exporting 87.68MW (11VR01+VR1transf_Pwr) to Victoria when a protection operation occurs resulting in a maximum frequency of 50.668Hz observed, however this is clearer viewing the tabulated results below.

Evaluation of TFR L2 Data			
Time (Seconds)	Bus Volts (kV RMS)	Frequency (Hz)	Power Flow (MW)
Reference	229.54	50.000	87.68
+0.41 (Loss Of Link Issued)	233.82	50.091	0
+5.02	230.60	50.668	0
+24.82	230.12	50.110	0

5.1.2 Example of System Event when Exporting:

The following is an example of a network event while the Basslink Interconnector is exporting:

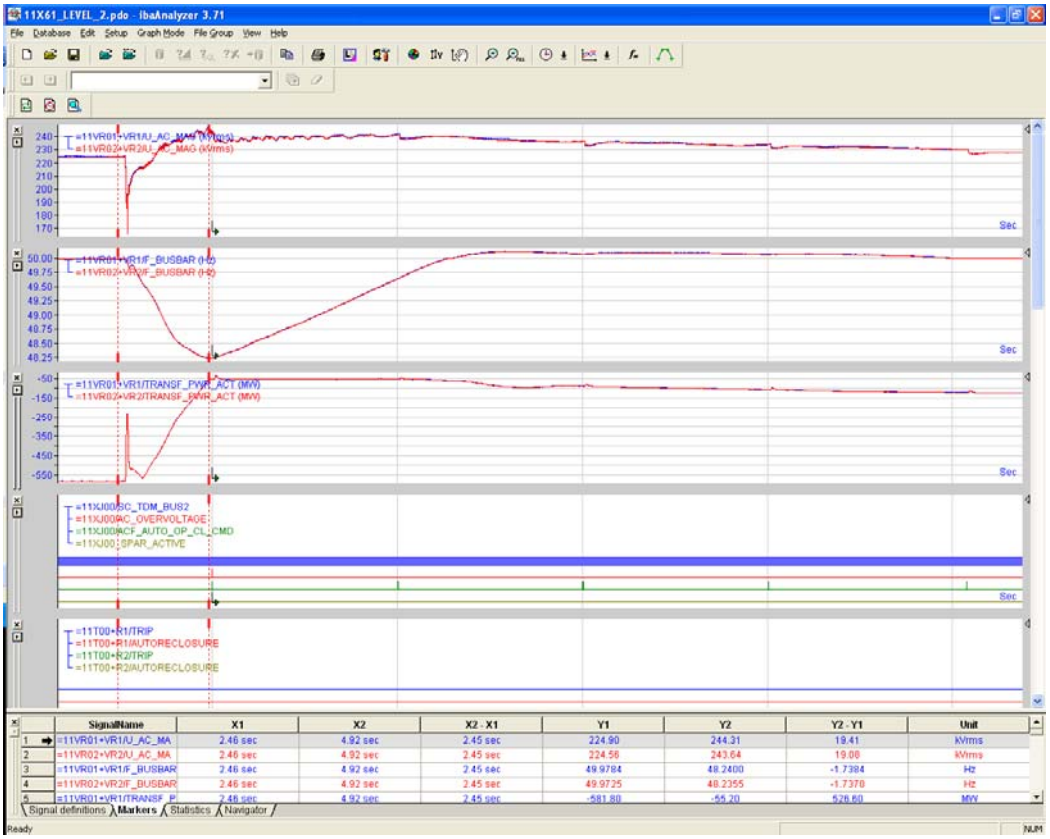

Diagram 4 Basslink Level 2 Transient Fault Record

Viewing Diagram 4 a steady state reference 2.46 seconds from the beginning of the record has been selected showing the interconnector is exporting 581.80MW (11VR01+VR1transf_Pwr) to Victoria when an AC event occurs resulting in a minimum frequency of 48.23551Hz observed, however this is clearer viewing the tabulated results below.

Evaluation of TFR L2 Data			
Time (Seconds)	Bus Volts (kV RMS)	Frequency (Hz)	Power Flow (MW)
Reference	224.90	49.9725	581.80
+2.45	244.31	48.2355	55.20
+23.56	227.92	49.9971	122.83

5.1.3 Example of System Event when Importing:

The following is an example of a network event while the Basslink Interconnector is importing:

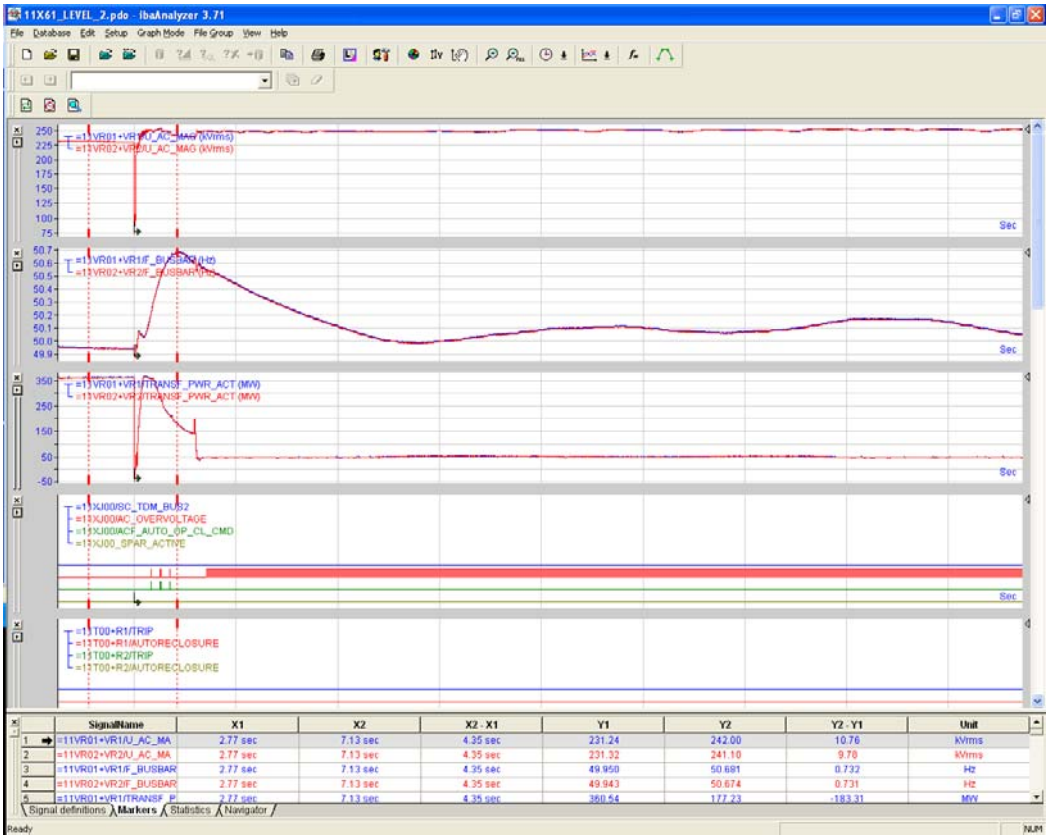

Diagram 5 Basslink Level 2 Transient Fault Record

Viewing Diagram 5 a steady state reference 2.77 seconds from the beginning of the record has been selected showing the interconnector is importing 360.54MW (11VR01+VR1transf_Pwr) to Tasmania when an AC event occurs resulting in a maximum frequency of 50.681Hz observed, however this is clearer viewing the tabulated results below.

Evaluation of TFR L2 Data			
Time (Seconds)	Bus Volts (kV RMS)	Frequency (Hz)	Power Flow (MW)
Reference	231.24	49.950	360.54
+4.35	242.00	50.681	177.23
+24.30	249.33	50.110	51.34

5.2 Economic Factors:

Basslink believes implementing a change to the frequency standard may require changes to generator frequency control as well as under / over frequency tripping schemes and to the Basslink frequency control function.

For Basslink the economic factors include:

- Cost associated with determining the new Basslink Objective Function that provides the comparison between the different standards for the frequency control error calculation
- Cost associated with NETOMAC simulation model and PSS/E Stability Model to determine parameter changes required
- Cost associated with implementing program changes
- Costs imposed on our customer as a result of these changes

If the frequency standard was changed during the project stage of the Basslink interconnector the engineering costs could have been absorbed with project funds but for changes at this time there are no operations and maintenance funds budgeted for the engineering resources required for changes beyond the design scope.

6 Summary:

In summary Basslink would fully support changes in the frequency standard based on current capabilities of the Tasmanian system utilising the inherent stability the addition on a HVDC interconnector provides to the interconnected networks and as such would not require design changes to the Basslink frequency controller function.

As frequency control is a stability function and offers no revenue stream to recover costs Basslink would not support changes to the frequency standard that require design changes to the Basslink frequency controller function without recourse to financial restitution.

7 DOCUMENT MANAGEMENT RECORD

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1.0	23/04/08	Initial Issue	G. Mather	J. Ferencz