

POWER SYSTEM OPERATING INCIDENT REPORT – TRIP OF BERRI NO 1 66KV BUSBAR AND THE MONASH – MURRAYLINK 132KV LINE ON 27 NOVEMBER 2012.

PREPARED BY: System Performance and Commercial

DATE: 6 March 2013

FINAL

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Abbreviations and Symbols

Abbreviation	Term
CB	Circuit Breaker
CBF	Circuit Breaker Failure
CT	Current Transformer
EMMS	Electricity Market Management System
EMS	Energy Management System
HVDC	High Voltage Direct Current
kV	Kilovolt
MW	Megawatt
S	Seconds; (ms = milliseconds)

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Incident summary

Date and time of incident	27 November 2012 at 0312 hrs
Region of incident	SA
Affected regions	SA
Event type	BB – Busbar trip
Primary cause	ENVI & LN – Environment and Lightning
Impact	Not significant
Associated reports	Nil

1 Introduction

At 03:11:55 hrs on 27 November 2012, the No.1 66 kV Busbar at Berri Substation tripped. A severe electrical storm was passing over the Riverland area at the time. The Monash – Murraylink-Berri 132 kV Transmission Line opened at the Murraylink Berri Converter Station end at 03:12:10 hrs approximately. Supply was interrupted to approximately 20 MW of load during this event.

This report has been prepared under clause 4.8.15 (c) of the National Electricity Rules (NER) to assess the adequacy of the provision and response of facilities and services and the appropriateness of actions taken to restore or maintain power system security.

This report is largely based upon information provided by ElectraNet, APA Group and SA Power Networks. Data from AEMO's Energy Management System (EMS) and Electricity Market Management System (EMMS) has also been used in analysing the incident.

All references to time in this report are to National Electricity Market time (Australian Eastern Standard Time), unless specified otherwise.

2 Pre-Contingent System Conditions

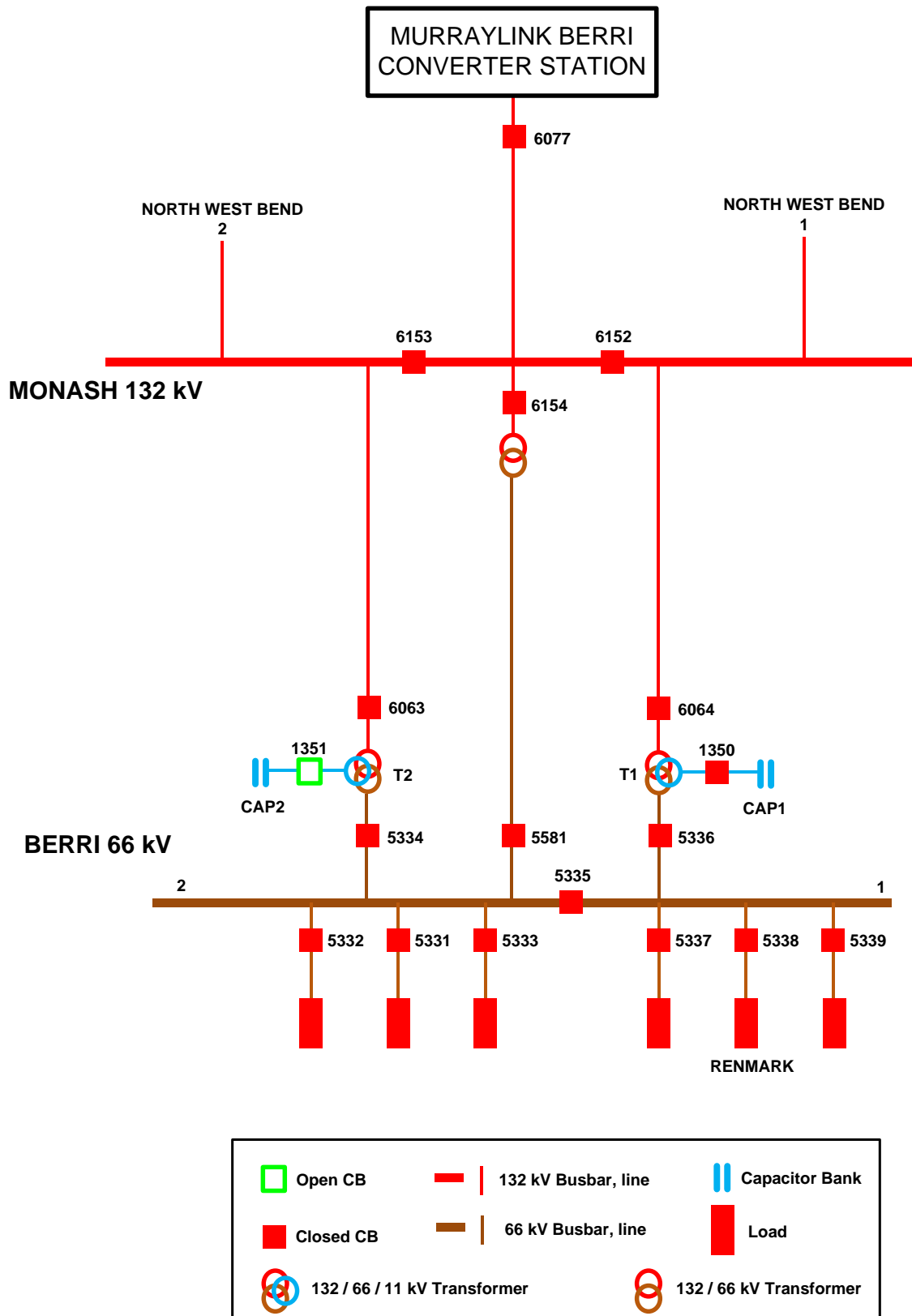
Prior to the event, the High Voltage Direct Current (HVDC) interconnection between South Australia and Victoria ('**Murraylink Interconnector**') was transferring 16 MW from South Australia to Victoria.

SA Power Networks has indicated that a severe electrical storm was passing over the Riverland area at the moment of the event.

The status of the power system prior to the incident is shown in Figure 1.

For clarity, only equipment relevant to this incident has been included in the diagram.

Figure 1 - Status of the power system prior to the incident



3 Summary of Events

At 03:11:55 hrs a fault occurred in the Berri – Renmark 66 kV Transmission Line at around 1.2 km from the Berri Substation. The line protection scheme operated in Zone 1 time¹ and cleared the fault by opening the CB 5338 at Berri Substation.

At the same time, a circuit breaker failure (CBF) signal for the Circuit Breaker (CB) 5338 at Berri Substation was initiated. The CBF alarm signal did not reset in the time required by the protection scheme and back-up protection action tripped the No.1 66 kV Busbar at Berri Substation approximately 330 ms later. Supply was interrupted to approximately 20 MW of load during this event.

Approximately 15 s later the CB 6077 at the Murraylink Berri Converter Station opened, offloading the Murraylink Interconnector.

The key events that took place during this incident are summarised in Table 1 below:

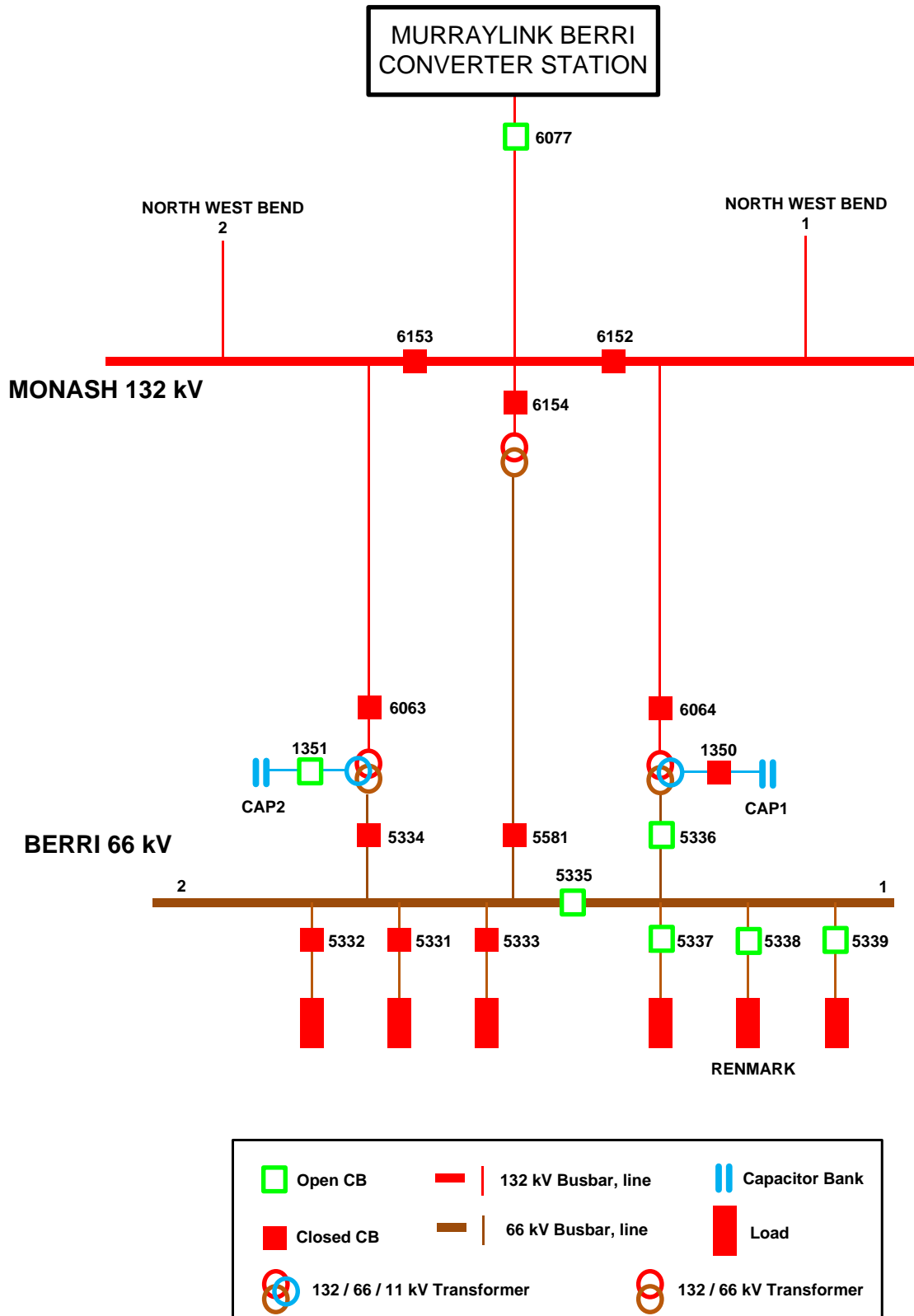
Table 1: Summary of events

Time	Events	Comments
03:11:55.104	CB 5338 at Berri Substation tripped on distance protection Zone 1.	Fault detected on the Berri – Renmark 66 kV line. Severe storm was present in the area. CBF signal initiated for CB 5338 at Berri Substation.
03:11:55.431	CBF protection activated for CB 5338 at Berri.	Although the CB 5338 tripped and successfully removed the fault, the circuit breaker fail signal did not reset on time due to residual magnetism in the CT.
03:11:55.468	Berri No.1 66 kV busbar tripped. (CBs 5335, 5336, 5337 and 5339 open).	Back-up protection control action tripped the Berri No.1 66 kV busbar.
03:12:10.703	CB 6077 at Murraylink Berri Converter Station tripped offloading Murraylink interconnector.	
03:19	Market Notice No.40406 issued, informing about the interconnection trip	
03:20	Constraint set I_ML_ZERO invoked.	
04:33	Berri No.1 66 kV busbar returned to service.	Load restoration started.
04:36	Market Notice No.40407 issued informing about the multiple contingency event and the loss of 20 MW of load approximately.	
04:54	Berri – Renmark 66 kV line returned to service.	
04:58	CB 6077 at Murraylink Berri Converter Station closed, returning the Murraylink interconnector to service.	
05:10	Constraint set I_ML_ZERO revoked.	
13:41	Market Notice No.40424 issued informing about the reclassification of the simultaneous trip of Berri No.1 66 kV busbar and Murraylink interconnector as a credible contingency event.	

¹ Distance protection relays usually have a reach setting of up to 80-85% of the protected line impedance for instantaneous Zone 1 protection.

The status of the power system immediately after the event is shown in Figure 3.

Figure 3 - Status of the power system immediately after the event



4 Immediate Actions Taken

AEMO issued Market Notice No.40406 at 0319 hrs informing about the HVDC interconnection trip and invocation of constraint set I-ML_ZERO.

At 0320 hrs AEMO invoked constraint set I_ML_ZERO.

5 Follow-up Actions

The No.1 66 kV Busbar at Berri Substation was returned to service at 0433 hrs. The load restoration started at the same time, with most of the load restored by 0500 hrs.

At 0458 hrs the CB 6077 at Murraylink Berri Converter Station was closed.

At 0510 hrs the constraint set I_ML_ZERO was revoked.

At the time of the event, the reason was not known for the offloading of the Monash – Murraylink-Berri 132 kV Transmission Line following the trip of the No.1 66 kV Busbar at Berri Substation. Accordingly at 1341 hrs AEMO issued Market Notice No.40424 declaring the simultaneous trip of the No.1 66 kV Busbar at Berri Substation and Murraylink Interconnector as a credible contingency event.

5.1 Berri No. 1 66 kV Bus Trip

Data provided by SA Power Networks indicates a three phase fault was present in the Berri – Renmark 66 kV Transmission Line. Both sets of line protection detected the fault and operated in zone 1 time, tripping CB 5338 at Berri Substation and clearing the fault in approximately 60 ms.

At the same time that the fault was detected, both sets of line protection issued a CBF initiate signal to the busbar zone 5 protection at Berri Substation. SA Power Networks has indicated that the secondary current of the CT supplying the CBF protection scheme did not subside in time due to residual magnetism in the CT and approximately 300 ms later the CBF condition for CB 5338 was declared by the busbar zone 5 protection at Berri Substation tripping the CBs 5335, 5336, 5337 and 5339.

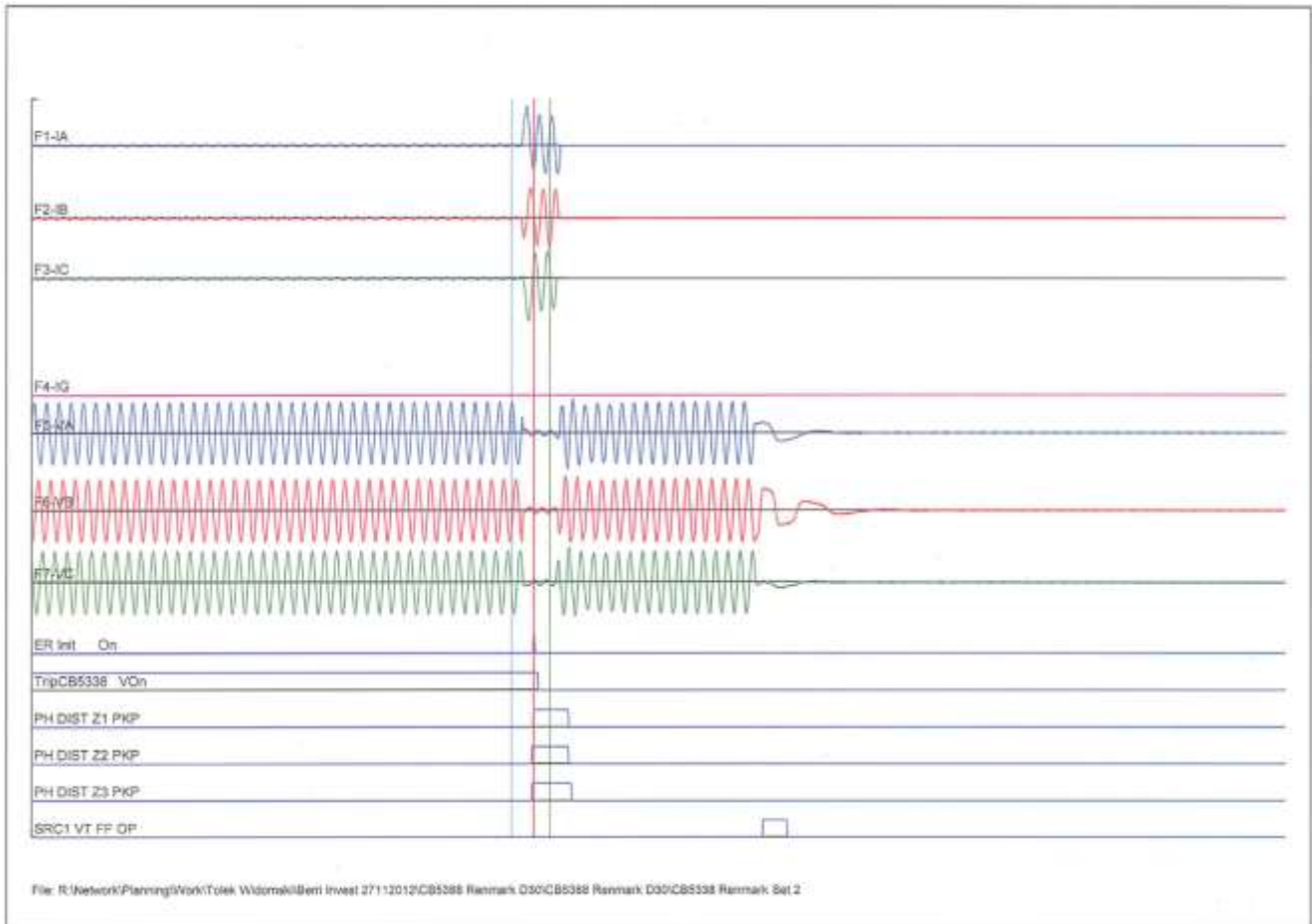
Information in Table 2 below was provided by SA Power Networks and shows the sequence of events at Berri Substation. It can be seen the Zone 1 trip indication for CB 5338 occurred at 03:41:55.104 hrs Australia Central Daylight Time (03:11:55.104 Market Time). The indication of CB 5338 opening, the CBF alarm for CB 5338 and the subsequent trip of the other CBs associated with the No.1 66 kV Busbar at Berri Substation are also shown.

Table 2: Summary of events

Date	Time	Location	Alarm	State	Tag	Ref	Commissioning
26-Nov-12	03:42:17:39	Berri	Loxton Communications Prot Signalling Fail	ACTIVE	A_CM399001M5	228	FALSE
26-Nov-12	03:42:17:47	Berri	Loxton Communications Prot Signalling Fail	INACTIVE	A_CM399001M5	228	FALSE
26-Nov-12	04:35:28:47	Berri	Loxton Communications Prot Signalling Fail	ACKNOWLEDGED	A_CM399001M5	228	FALSE
26-Nov-12	20:25:09:918	Berri	Renmark [CB5338] S2 Dist Z Volt Ref Fail	ACTIVE	A_LN399338VRF2	58	FALSE
26-Nov-12	20:25:12:978	Berri	Glossop [CB5332] Set 2 Dist Z Volt Ref Fail	ACTIVE	A_LN399166VRF2	58	FALSE
26-Nov-12	20:25:09:970	Berri	Renmark [CB5338] S2 Dist Z Volt Ref Fail	INACTIVE	A_LN399338VRF2	58	FALSE
26-Nov-12	20:25:13:31	Berri	Glossop [CB5332] Set 2 Dist Z Volt Ref Fail	INACTIVE	A_LN399166VRF2	58	FALSE
26-Nov-12	20:33:49:31	Berri	Glossop [CB5332] Set 2 Dist Z Volt Ref Fail	ACKNOWLEDGED	A_LN399166VRF2	58	FALSE
26-Nov-12	20:34:12:970	Berri	Renmark [CB5338] S2 Dist Z Volt Ref Fail	ACKNOWLEDGED	A_LN399338VRF2	58	FALSE
27-Nov-12	03:41:55:99	Berri	Glossop [CB5332] Set 1 Dist Z Volt Ref Fail	ACTIVE	A_LN399166VRF1	58	FALSE
27-Nov-12	03:41:55:104	Berri	Renmark [CB5338] S2 Distance Z Zone 1 Trip	ACTIVE	A_LN399338ZT21	108	FALSE
27-Nov-12	03:41:55:107	Berri	CB5338 [Renmark] S1 Reclose Initiate	ACTIVE	A_LN399338R11	108	FALSE
27-Nov-12	03:41:55:107	Berri	Renmark [CB5338] S1 Distance Z Zone 1 Trip	ACTIVE	A_LN399338ZT11	108	FALSE
27-Nov-12	03:41:55:107	Berri	Renmark [CB5338] S1 Line Diff & Dist Z Ph 3 Trip	ACTIVE	A_LN399338DITZ1	108	FALSE
27-Nov-12	03:41:55:107	Berri	Renmark [CB5338] S1 Line Diff & Dist Z Ph 2 Trip	ACTIVE	A_LN399338DITY1	108	FALSE
27-Nov-12	03:41:55:107	Berri	Renmark [CB5338] S1 Line Diff & Dist Z Ph 1 Trip	ACTIVE	A_LN399338DITX1	108	FALSE
27-Nov-12	03:41:55:119	Berri	Renmark [CB5338] S2 Distance Z Trip	ACTIVE	A_CB005338DIT2	108	FALSE
27-Nov-12	03:41:55:120	Berri	Renmark [CB5338] S1 Distance Z Trip	ACTIVE	A_CB005338DIT1	108	FALSE
27-Nov-12	03:41:55:133	Berri	CB5338 [Renmark] Open	ACTIVE	A_CB005338ZC	178	FALSE
27-Nov-12	03:41:55:431	Berri	CB5338 [Renmark] CB Failed To Trip	ACTIVE	A_CB005338MT	58	FALSE
27-Nov-12	03:41:55:461	Berri	CB5337 [Transformer 3] Open	ACTIVE	A_CB005337ZC	178	FALSE
27-Nov-12	03:41:55:464	Berri	CB5339 [Lyrup] Open	ACTIVE	A_CB005339ZC	178	FALSE
27-Nov-12	03:42:01:0	Berri	CB5336 [TF 1] Open	ACTIVE	A_CB005336ZC	178	FALSE
27-Nov-12	03:41:55:468	Berri	CB5335 [66kV Section] Open	ACTIVE	A_CB005335ZC	178	FALSE
27-Nov-12	03:41:55:479	Berri	Renmark [CB5338] S2 Dist Z Volt Ref Fail	ACTIVE	A_LN399338VRF2	58	FALSE
27-Nov-12	03:41:56:783	Berri	Glossop [CB5332] Set 2 Dist Z Volt Ref Fail	ACTIVE	A_LN399166VRF2	58	FALSE
27-Nov-12	03:41:57:361	Berri	Renmark [CB5338] S2 Dist Z 3-Ph to Gnd Fil Trip	ACTIVE	A_LN399338PFT	108	FALSE
27-Nov-12	03:41:55:104	Berri	Glossop [CB5332] Set 1 Dist Z Volt Ref Fail	INACTIVE	A_LN399166VRF1	58	FALSE
27-Nov-12	03:41:55:187	Berri	Renmark [CB5338] S2 Distance Z Zone 1 Trip	INACTIVE	A_LN399338ZT21	108	FALSE
27-Nov-12	03:41:55:184	Berri	Renmark [CB5338] S2 Distance Z Trip	INACTIVE	A_CB005338DIT2	108	FALSE
27-Nov-12	03:41:55:519	Berri	Renmark [CB5338] S2 Dist Z Volt Ref Fail	INACTIVE	A_LN399338VRF2	58	FALSE
27-Nov-12	03:41:55:519	Berri	Renmark [CB5338] S1 Distance Z Trip	INACTIVE	A_CB005338DIT1	108	FALSE
27-Nov-12	03:41:56:0	Berri	CB5338 [Renmark] CB Failed To Trip	INACTIVE	A_CB005338MT	58	FALSE

Figure 4 below, shows the current and voltage waves on the Berri – Renmark 66 kV Transmission Line at the time of the event. The fault was effectively cleared by the action of the line protections causing the CB 5338 to open, but approximately 300 ms later the busbar was unnecessarily tripped by CBF protection.

Figure 4 – Berri – Renmark 66 kV line – set 2 line protection (GE D30) oscillograph record



SA Power Networks has informed that the problem with the CT has been temporarily addressed by adjusting the pickup level of the 66 kV CBF protection to consider any expected CT residual current following a close-in asymmetrical line fault. A permanent solution is planned by July 2013 consisting of the installation of additional wiring at the substation to allow for a selection of higher ratio CTs and thereby minimise the residual CT current problem.

5.2 Murraylink Interconnector Trip

APA Group has advised that the trip of CB 6077 at Murraylink Berri Converter Station was due to operation of the valve and reactor cooling protection system which responded to a low cooling water flow rate.

The fault in the Berri – Renmark 66 kV Transmission Line and the subsequent trip of the No.1 66 kV Busbar at Berri Substation caused the loss of auxiliary power supply to the Murraylink Berri Converter Station, which caused the failure of the cooling water pumps, and the subsequent low cooling water flow rate.

The Murraylink Berri Converter Station has two sources of auxiliary supply. The 'A' supply is taken from the tertiary winding of the power transformer at the converter station. The 'B' supply is taken from the local SA Power Networks 11 kV distribution network supplied from Berri Substation.

Both auxiliary supplies are fitted with under-voltage and over-current protection release. There is an automatic change-over scheme between the 'A' and 'B' auxiliary supplies, designed to operate with a 4 second delay. The under-voltage release prevents the 'B' auxiliary supply from closing if the 'B' auxiliary voltage is below 85% of rated voltage.

Due to the under-voltage caused by the fault in the Berri – Renmark 66 kV Transmission Line, the 'A' auxiliary supply at the Murraylink Berri Converter Station opened, but the change-over scheme to connect to the 'B' auxiliary supply source did not operate in time which caused an interruption of auxiliary power supply to the Murraylink Berri Converter Station.

According to the information available, it is unlikely that the fault in the Berri – Renmark 66 kV Transmission Line, which was cleared in approximately 60 ms, could significantly affect the 'B' auxiliary voltage supply to prevent the correct operation of the change-over scheme at the Murraylink Berri Converter Station.

APA Group has identified a set of credible conditions that could cause the loss of auxiliary power. APA Group is planning to modify the control of the auxiliary power supply to prevent a future trip under similar conditions.

The next planned outage for Murraylink Berri Converter Station is on 13 March 2013 and APA Group is aiming to implement the required changes to the auxiliary power control during this shutdown.

6 Power System Security Assessment

Elsewhere in the power system, voltages were within limits and the frequency remained within the normal operating bands specified in the Frequency Operating Standards. The power system remained in a secure operating state throughout the incident.

At 1341 hrs, AEMO issued Market Notice No.40424 declaring the loss of the No.1 66 kV Busbar at Berri Substation and Murraylink Interconnector as a credible contingency event. However, the reclassification should have been done earlier; for example when the Murraylink Interconnector returned to service at approximately 0500 hrs.

The delay in the reclassification did not impose any risk to the power system.

The reclassification of the No.1 66 kV Busbar at Berri Substation and Murraylink Interconnector as a credible contingency event will remain in place until APA Group implements the required modifications to the control of the auxiliary power supply.

According to SA Power Network information, CBF protection of CB 5338 at Berri Substation did not operate as intended. The CB 5338 opened successfully clearing the fault, but the CBF signal did not reset within the required time, resulting in the unnecessary tripping of the No.1 66 kV Busbar at Berri Substation. SA Power Network has in place temporary measures to manage this defect and will implement a definitive solution by July 2013.

The Murraylink Interconnector tripped due to issues with the auxiliary supply change over scheme at the Murraylink Berri Converter Station. APA Group is planning to implement the required modifications to the auxiliary power control during an outage planned in March 2013.

7 Conclusions

The Berri – Renmark 66 kV Transmission Line tripped during a period when lightning was in the vicinity of the line. The line protection operated adequately and cleared the fault; however the occurrence of a CBF signal that did not reset in time caused back-up protection to initiate a trip of the No.1 66 kV Busbar at Berri Substation.

Residual magnetism in a CT was identified as the causer of the maloperation of the CBF protection for the CB 5338 at Berri Substation. SA Power Network has implemented a temporary solution and will apply a permanent solution by July 2013.

The trip of the Murraylink Interconnector was due to loss of auxiliary supply to the converter station which caused the shutdown of the cooling water pumps, and the subsequent low cooling water flow rate.

APA Group has identified some issues with the control for the auxiliary supply change-over at Murraylink Berri Converter Station and is planning to correct them during the next planned outage on 13 March 2013.

AEMO correctly applied the criteria published in section 12 of its Power System Security Guidelines in reclassifying this multiple event as credible contingency event. However there was some delay in declaring this reclassification. This delay did not affect the security of the power system,

Most of the lost load was restored by 0500 hrs.

8 Recommendations

SA Power Network should implement a permanent solution to the CT residual magnetism issue on the CT that supplies the CBF protection for the CB 5338 at Berri Substation. This solution is expected by July 2013 and SA Power Network should inform AEMO on completion.

APA Group should implement modifications to the control for the auxiliary supply change-over at Murraylink Berri Converter Station to avoid future maloperation of the scheme. This modification is planned by the 13 March 2013 and APA Group should inform AEMO on completion.

AEMO to review its procedures to ensure reclassifications occur in the appropriate time. AEMO will complete this action by 31 March 2013.