Electrical Data Manual

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Responsible Officer: Network Performance Engineer
Procedure Custodian: Branch Manager Asset Strategy and Planning
Division: Asset Management
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1. Scope

To provide information required in the design and operation of the electrical network.

2. Purpose

Electrical characteristics of zone substations, underground cables, overhead conductors, reservation and easements for use in the design and operation of the ActewAGL electrical network.

3. Procedure

Note:
This document is best viewed in Page Layout view; with a magnification at page width; and with table grid lines turned off.
It is advised that a link to this document be placed on the desktop for easy access.
Use the hyperlinks to navigate through the document.

3.1. Disclaimer

Care has been taken in the preparation of this manual. However in a number of cases the equipment data was not available or could not be easily confirmed. In such situations whenever possible explanatory comments have been provided. It is advised that in the case of significant decisions, the data from this manual should be cross referenced with the data from other sources.

Please report any errors or omissions to Manager Asset Strategy and Planning..

5. CONTENTS

If not specified otherwise, shaded areas of the data tables contain the values most commonly used in the calculations.

ZONE SUBSTATION INFORMATION

Z/S - TRANSFORMER SUMMARY

Contents - Zone Substation Information - **Transformer Summary**
- Transformer Ratings
- Transformer Impedances and Tap Information
- Notes

Location & Tx No.	Manufacturer	Serial No.	Year of Manufacture	Winding Vector - see AS 2374-1982	Voltage Zone (kV) (a)	ONAN Rating (MVA) (b)	ODAN Rating (MVA) (b)	OFAF Rating (MVA) (b)	2 Hour Emergency Rating (c)		Winding Hotspot Temperature (°C)		No. of radiators/ fans. (b)
									(MVA) Summer	(MVA) Winter	Summer	Winter	
Belconnen Tx1 (AT)	GEC	A31U3762/1	1988	YNd1	132	30	35	55	74	81	139	138	16/20 (b1)
Belconnen Tx2 (BT)	GEC	A31U3762/2	1988	YNd1	132	30	35	55	74	81	139	138	16/20 (b1)
City East Tx1 (AT)	Tyree (ABB)	70850	1978	YNd1	132	35	43	57	79	88	139	141	12/16 (b2)
City East Tx2 (BT)	GEC	A31R3612/3 (d)	1986	YNd1	132	30	35	55	74	81	139	138	16/20 (b3)
City East Tx3 (CT)	Tyree (ABB)	70851	1978	YNd1	132	35	43	57	78	87	139	141	12/16 (b2)
Civic Tx1 (AT)	GEC	A31R3612/2 (d)	1986	YNd1	132	30	35	55	74	81	139	138	16/20 (b3)
Civic Tx2 (BT)	GEC	A31R3612/1 (d)	1986	YNd1	132	30	35	55	78	86	140	141	16/20 (b3)
Civic Tx3 (CT)	ABB	VN00621	2011	YNd1	132	30	35	55	72	77			8/7
Fyshwick Tx1 (AT)	ABB	400141-1	2005	Dyn1	66	16	20 (b4)	NA	26.2	29.9	140	140	5/4
Fyshwick Tx2 (BT)	Wilson	P0718A	2007	Dyn1	66	15	25	NA	30	30	140	140	9/0
Fyshwick Tx3 (ZT) (f)	Wilson	P1310-01	2013	Dyn1	66	25	-	-	28	28			7
Gilmore Tx1 (AT)	Tyree	22469	1966	YNd1	132	30	38 ob	45 ofb	62	69	141	141	8/16
Gilmore Tx3 (CT)	Tyree	22467	1966	YNd1	132	30	38 ob	45 ofb	62	69	141	141	8/16
Gold Creek Tx1 (AT)	Wilson	95399	1993	YNd1	132	34.5	40	57	74	84	141	140	9/12
Gold Creek Tx3 (CT)	Wilson	95398	1993	YNd1	132	34.5	40	57	77	85	138	140	9/12
MoSS Tx1 (AT)	ABB	VN00436	2009	YNd1	132	10	NA	15 onaf					
Latham Tx1 (CT)	Tyree	70976	1981	YNd1	132	30	37.5	50	73	81	137	138	10/12
Latham Tx2 (AT)	Tyree	70131	1970	YNd1	132	30	40 ob	50 ofb	71	78	140	141	9/16
Latham Tx3 (BT)	Tyree	70132	1970	YNd1	132	30	40 ob	50 ofb	71	78	140	141	9/16
Telopea Park Tx1 (AT)	Tyree	140088	1985	YNd1	132	30	37.5	50	70	78	140	141	10/12
Telopea Park Tx2 (BT)	Tyree	140089	1985	YNd1	132	30	37.5	50	73	80	141	141	10/12
Telopea Park Tx3 (CT)	Tyree	70984	1983	YNd1	132	30	37.5	50	74	82	141	141	10/12
Theodore Tx1 (AT)	Tyree	22468	1966	YNd1	132	30	38 ob	45 ofb	62	69	141	141	8/16
Theodore Tx3 (CT)	Tyree	22470	1967	YNd1	132	30	38 ob	45 ofb	62	69	141	141	8/16
Wanniassa Tx1 (CT)	Tyree	70867	1979	YNd1	132	30	37.5	50	74	82	140	140	10/12
Wanniassa Tx2 (AT)	Tyree	70696	1974	YNd1	132	30	40 (b4)	50	70	78	140	140	9/16
Wanniassa Tx3 (BT)	Tyree	70697	1974	YNd1	132	30	40 (b4)	50	70	78	140	140	9/16
Woden Tx1 (AT)	Tyree	70798	1977	YNd1	132	30	37.5	50	74	82	139	139	10/12
Woden Tx2 (BT)	Tyree	70797	1977	YNd1	132	30	37.5	50	74	82	139	139	10/12
Woden Tx3 (ZT)	Tyree	70983	1982	YNd1	132	30	37.5	50	73	81	140	140	10/12

Z/S - TRANSFORMER IMPEDANCES AND TAP INFORMATION

Contents - Zone Substation Information - Transformer Summary

- Transformer Ratings
- **Transformer Impedances and Tap Information**
- Notes

Location & Tx No.	Voltage Zone (kV) (a)	Positive sequence resistance, R1 (% pu/phase) (g)	Positive sequence reactance, X1 (%pu/phase) (g)	Positive sequence impedance, Z1 (% pu/phase) (g)	Z0, Star side of Transformer (ohms/phase) (g), (h)	Taps		
						Max Voltage (pu)	Min Voltage (pu) / Tap No.	Step (pu voltage)
Belconnen Tx1 (AT)	132	0.39	16.59	16.6 (g1)	78.7	1.05	0.79/27	0.010
Belconnen Tx2 (BT)	132	0.40	16.45	16.5	79.4	1.05	0.79/27	0.010
City East Tx1 (AT)	132	0.43	16.24	16.3	**	1.05	0.79/27	0.010
City East Tx2 (BT)	132	0.39	16.58	16.6	**	1.05	0.79/27	0.010
City East Tx3 (CT)	132	0.43	16.19	16.2	**	1.05	0.79/27	0.010
Civic Tx1 (AT)	132	0.39	16.70	16.7	78.9	1.05	0.79/27	0.010
Civic Tx2 (BT)	132	0.39	16.64	16.6	78.9	1.05	0.79/27	0.010
Civic Tx3 (CT)	132	?	?	?	?	?	?	?
Fyshwick Tx1 (AT) (at tap 1/8/12/22)	66	0.41/0.42/0.43/0.54	9.84/9.36/9.13/8.78	9.8/9.4/9.1/8.8	0.738/0.705/0.687/0.659	1.105	0.790/22	0.015
Fyshwick Tx2 (BT)	66	0.36	10.7	10.7	0.851	1.105	0.79/22	0.015
Fyshwick Tx3 (ZT) (f)	66	0.48	10.27	10.28	0.444	1.05	0.8 /21	0.0125
Gilmore Tx1 (AT)	132	0.57	20.69	20.7 (g2)	96.5	1.06	0.79/19	0.015
Gilmore Tx3 (CT)	132	0.58	20.49	20.5	**	1.06	0.79/19	0.015
Gold Creek Tx1 (AT)	132	0.28	16.63	16.6 (g3)	76.7	1.05	0.79/27	0.010
Gold Creek Tx3 (CT)	132	0.27	16.57	16.6	76.5	1.05	0.79/27	0.010
Latham Tx1 (CT)	132	0.43	16.28	16.3	79.9	1.05	0.79/27	0.010
Latham Tx2 (AT)	132	0.39	17.04	17.0 (g4)	81.1	1.06	0.79/19	0.015
Latham Tx3 (BT)	132	0.39	16.69	16.7	**	1.06	0.79/19	0.015
MoSS Tx1 (AT)	132			6.82		1.10	0.85/26	0.010
Telopea Park Tx1 (AT)	132	0.43	16.26	16.3	**	1.05	0.79/27	0.010
Telopea Park Tx2 (BT)	132	0.43	16.19	16.2	**	1.05	0.79/27	0.010
Telopea Park Tx3 (CT)	132	0.42	16.56	16.6	**	1.05	0.79/27	0.010
Theodore Tx1 (AT)	132	0.54	20.49	20.5 (g5)	**	1.06	0.79/19	0.015
Theodore Tx3 (CT)	132	0.59	20.69	20.7	96.2	1.06	0.79/19	0.015
Wanniassa Tx1 (CT)	132	0.42	16.27	16.3 (g6)	**	1.05	0.79/27	0.010
Wanniassa Tx2 (AT)	132	0.41	17.04	17.0	**	1.06	0.79/19	0.015
Wanniassa Tx3 (BT)	132	0.42	16.80	16.8	**	1.06	0.79/19	0.015
Woden Tx1 (AT)	132	0.43	16.55	16.6	80.2	1.05	0.79/27	0.010

Woden Tx2 (BT)	132	0.40	16.43	16.4	**	1.05	0.79/27	0.010
Woden Tx3 (ZT)	132	0.43	16.34	16.4	**	1.05	0.79/27	0.010

(a) For transformers in the 132 kV zone:
These transformers have rated voltages 132 kV/11 kV (1 pu) and are of three limb core type construction, with neutral connected directly to earth. Rated voltages are obtained on Tap 6 (for 27 tap transformers) or Tap 5 (for 19 tap transformers). Where data is not provided then this data has not been readily available. All information has been obtained from nameplate or manufacturer test results (some conversion and correction of manufacturers' data may have been undertaken). Some discrepancies may exist between manufacturer test report and nameplate data. Transformers have tappings on 132 kV star side, with maximum tap voltage either 1.06 pu = 139.92 kV (19 tap) or 1.05 pu=138.6 kV (27 tap) and all have minimum tap 0.79 pu=104.28 kV, to produce 11.0 kV on delta side. Tap steps are either 0.010 pu (1.32 kV) for 27 tap transformers or 0.015 pu (1.98 kV) for 19 tap transformers . Tap No. is as per nameplate, with Tap No. 1 corresponding to the minimum secondary voltage and tap 27 (or tap 19) to the maximum secondary voltage boost.
For transformers in the 66 kV zone:
All transformers have rated voltages of 66 kV / 11 kV with 11 kV star side neutral connected directly to earth. All transformers have on load tapchangers with 22 taps on 66 kV delta side, to maintain 11 kV on star side. Tap range is from Tap 1 (72930 V = 1.105 pu) to Tap 22 (52140 V = 0.79 pu), in steps of 990 V (=0.015 pu). Tap 8 is rated voltage of 66/11 kV (1pu/1pu). These transformers have only fans for additional cooling and do not have pumps. TX2 has pumps and no fans.

(b) Transformer power ratings are up to date nameplate values, and therefore represent the minimum continuous power available under the purchase contract (ie slightly higher values may be available following detailed analysis of the heat run test data). Transformer power ratings may be different to manufacturer original (i.e. at purchase) factory test results nameplate values as some transformers have had additional radiators/fans installed to increase rating. The transformer radiators/fan column with numbers marked (b1), (b2), or (b3) have previously had additional radiators/fans installed in 1990 to the numbers shown, to increase the OFDAF rating to the value shown in this table, and on modified nameplates. Original numbers of radiators/fans and ratings were:
b1 – 10/16, originally 30/35/50MVA.
b2 – 10/12, originally 30/37.5/50MVA.
b3 – 12/16, originally 30/35/50MVA.
For use in this table no distinction is made between "OF" and "OFD" or "OD", for oil cooling, so transformers could be either. Transformer nameplate ratings marked "ob" and "ofb" are assumed equivalent to ODAN and OFDAF respectively.
b4- Transformer ratings marked with (b4) are ONAF ratings (not ODAN) according to nameplate.

(c) 2 Hour Emergency Ratings are calculated using:
Winter ambient temperature: 15°C
Summer ambient temperature: 35°C
The maximum number of times per year any of the transformers can be in 2 hours emergency operation mode is 10. Emergency ratings are limited by the calculated hot spot winding temperature limit of 140 C.

(d) There is a discrepancy between transformer name plate and test reports identification numbers. These transformers may have test reports marked as A3R3612/1,2 or 3 instead of the nameplate serial number A31R3612/1, 2 or 3.

(e) Transformer 11kV bushings are rated continuously at 1000 Amps (ref.: electronic mail – Friday 18/06/1999, from Silvano Forlin; Subject: "FW: Heat Run Test on Fyshwick Zone Substation Transformer 11kV Bushing", in file ref. G79/65 (Electrical Systems – Operations and Maintenance – Fyshwick 66kV Substation).

(f) This transformer was 'factory' refurbished in 2000. After refurbishment the values of Z1 and Z0 have been determined through testing.

(g) For transformers in the 132 kV zone substations , the determination of transformer positive sequence values (Z1, R1, X1) is based on 30 MVA (even if the ONAN rating is different to this) and at 75°C winding temperature, using rated voltage and taps (i.e. tap 6 for 27 taps, tap 5 for 19 taps), and stated on a per phase basis, obtained from manufacturer test results (not necessarily the same as nameplate data).
For the 66 kV transformers at Fyshwick Zone, the determination of transformer positive sequence values (Z1, R1, X1) are based on the ONAN rating (either 15MVA for Tx2, and 16MVA for Tx1&Tx3), at rated voltage (including those not on nominal tap).

For 132 kV transformers zero sequence impedance Z0 does not include impedance of the separate earthing transformer.

Note: |Z1|=|R1+jX1|. Values of R1 obtained by calculation from load loss kW value (i.e. excludes no load losses) at 30 MVA. Values of R1and X1 are stated to 2 decimal places; Z1 values are stated (rounded up or down) to 1 decimal place, so may appear less than X1 is some cases. Some transformers have different nameplate values (some are incorrect) to manufacturer test results, and have been included below for completeness:
g1) Belconnen Tx1 S/N A31U3762/1- Nameplate states Z1= 16.59% (rounded for above table).
g2) Gilmore Tx1 S/N 22469 - Nameplate states Z1=20.3% (this appears to be the specification guarantee value).
g3) Gold Creek Tx1 S/N 95399 - Nameplate states Z1= 16.26%.
g4) Latham Tx2 S/N 70131 - Nameplate states Z1= 16.94% (rounded for above table).
g5) Theodore Tx1 S/N 22468-The value shown in table (20.5%) is the nameplate value that manufacturer tested at time of manufacture. After repairs were carried out in 1977, manufacturer retest indicated Z1= 20.69%.
g6) Wanniassa Tx1 S/N 70867- Nameplate states Z1= 16.71% (this appears to be the Tap 1 impedance value).

(h) The Zero sequence impedance (Z0), is assumed entirely reactive, measured on rated voltage taps, with winding temperature generally not stated. If no values are shown, then for an approximate value for calculation purposes it can be assumed the zero

sequence impedance is entirely reactive and equal to 0.8 of the positive sequence impedance, Z1, shown in the table.
These Z0 ohms values provided are calculated on the star side of the transformer i.e. 11 kV side for the 66/11 kV transformers and 132 kV side for the 132/11 kV transformers. Values are shown rounded to one decimal place if Zo greater than 10, and up to 3 decimal places if less than 10.

** - Value is to be calculated / obtained.
NA – Not Available / Not Applicable.

Top Of This Section

ANGLE CROSSING MOBILE ZONE SUBSTATION

Contents - Zone Substation Information – **Angle Crossing Mobile Zone Substation**
- Two Hour Emergency Rating
- Continuous Rating
- Normal & Emergency Operation (ZSS Diagram)

Assumptions:
The transformer tails current carry capacity for 630mm2 Cu cable has been taken from existing zone substation calculations. CYMCAP software shall be used to calculate the current carrying capacity for the specific installation at the MoSS.

Z/S – ANGLE CORSSING MOBILE - TWO HOUR EMERGENCY RATING

Contents - Zone Substation Information – Angle Crossing Zone Substation
- **Two Hour Emergency Rating**
- Continuous Rating
- Normal & Emergency Operation (ZSS Diagram)

EQUIPMENT "2 HOUR EMERGENCY" RATING			TX 1
TRANSFORMER		(Summer/Winter) (MVA) (LV Amps) (HV Amps)	 20/21 1050/1100 85/90 (ABB)
OLTC		(HV Amps)	150
HV Bushings		(HV Amps)	1600
LV Bushings	(4)		-
TX Cables (Copper PILC)		(Summer/Winter) (LV Amps per Circuit) (Cable Size)	 1760/2040 (630mm^2 Cu)
Group Busbar		(LV Amps) (Type)	2500 (ABB ZS1)
Group Circuit Breakers and Bus-Coupler		(LV Amps)	N/A
ZONE EMERGENCY RATING (MVA)			20/21

Notes:
(1) Summer limit
(2) Winter limit
(3) Rating of the substation is limited by the rating of the transformer. Emergency rating of the zone substation is 20/21 MVA total (summer/winter).
(4) This is a continuos rating. It has been assumed that the 2 hour bushing rating is 25% above the continuous rating.
(5) Ratings below 100 A are given to the nearest 1 A, and ratings above 100 A are given to the nearest 5 A.
(6) Transformer cable ratings require closer assessment and confirmation

Top Of This Section

Z/S – ANGLE CROSSING - CONTINUOUS RATING

Contents - Zone Substation Information – Angle Crossing Zone Substation
- Two Hour Emergency Rating
- **Continuous Rating**
- Normal & Emergency Operation (ZSS Diagram)

EQUIPMENT "CONTINIOUS" RATING		TX 1
TRANSFORMER	(Summer/Winter) (MVA) (LV Amps) (HV Amps)	 15 785 65 (ABB)
OLTC	(HV Amps)	150
HV Bushings	(HV Amps)	1600
LV Bushings (4)		-
TX Cables (Copper PILC)	(**Summer**/Winter) (LV Amps per Circuit) (Cable Size)	 1760/2040 (630mm^2 Cu)
Group Busbar	(LV Amps) (Type)	2500 (ABB)
Group Circuit Breakers and Bus-Coupler	(LV Amps)	N/A
ZONE CONTINIOUS RATING (MVA)		15

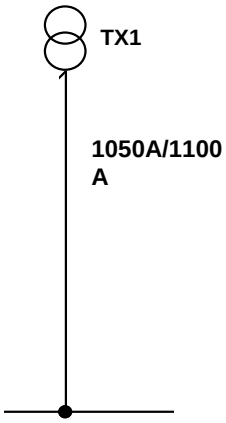
Notes:
(1) Summer and Winter limit
(2) Maximum continuous rating
(3) Note that the continuous rating for some equipment (OLTC, HV Bushings, LV Bushings, TX Cables, Group Busbar, Group CB's, and Bus-Coupler) is the same as the emergency rating.
(4) Ratings below 100 A are given to the nearest 1 A, and ratings above 100 A are given to the nearest 5 A.
(5) Transformer cable ratings require closer assessment and confirmation

Top Of This Section

Z/S – ANGLE CROSSING - NORMAL & EMERGENCY OPERATION (ZSS DIAGRAM)

Contents - Zone Substation Information – Angle Crossing Mobile Zone Substation
- Two Hour Emergency Rating
- Continuous Rating
- **Normal & Emergency Operation (ZSS Diagram)**

Normal Operation



Top Of This Section

BELCONNEN ZONE SUBSTATION

Contents - Zone Substation Information - **Belconnen Zone Substation**
- Two Hour Emergency Rating
- Continuous Rating
- Normal & Emergency Operation (ZSS Diagram)

Z/S - BELCONNEN - TWO HOUR EMERGENCY RATING

Contents - Zone Substation Information - Belconnen Zone Substation
- **Two Hour Emergency Rating**
- Continuous Rating
- Normal & Emergency Operation (ZSS Diagram)

EQUIPMENT "2 HOUR EMERGENCY" RATING			TX 1	TX 2
TRANSFORMER		(Summer/Winter) (MVA) (LV Amps) (HV Amps)	 74/81 3885/4250 325/355 (GEC)	 74/81 3885/4250 325/355 (GEC)
OLTC		(HV Amps)	500	500
HV Bushings		(HV Amps)	1250	1250
LV Bushings	(4)	(Amps per 2 bushings)	4000	4000
TX Cables (Copper PILC)		**(Summer/Winter)** (LV Amps per Circuit) (Cable Size)	**(1)/(2)** **1660/2000** (630 mm^2)	**(1)/(2)** **1660/2000** (630 mm^2)
Group Busbar		(LV Amps) (Type)	2000 (Brush)	2000 (Brush)
Group Circuit Breakers and Bus-Coupler		(LV Amps)	2000 (Brush)	2000 (Brush)
ZONE EMERGENCY RATING (MVA)			**(3)** **63/76** **Summer/Winter**	

Notes:
(1) Summer limit
(2) Winter limit
(3) Rating of the substation is limited by the rating of the transformer cables, i.e. 63/76 MVA total (summer/winter).
(4) This is continuos rating. It has been assumed that the 2 hour bushing rating is 25% above the continuous rating.
(5) If the maximum allowable firm rating of each transformer is based on half of the emergency rating then in the event of a failure of any one transformer the current in the transformer cables would be 1940/2120 Amps (summer/winter) - Calculations are shown in Normal & Emergency Operation (ZSS Diagram). The emergency rating of the zone substation is therefore limited by the transformer cables.
(6) Note that the continuous rating for some equipment (OLTC, HV Bushings, LV Bushings, TX Cables, Group Busbar, Group CB's, and Bus-Coupler) is the same as the emergency rating.
(7) The CT's for transformer differential protection (on 11kV Group CB's) are rated at 1925 Amps.
(8) The small difference between this and the winter rating of the transformer cables is considered to have no effect on the emergency rating.
(9) Ratings below 100 A are given to the nearest 1 A, and ratings above 100 A are given to the nearest 5 A.
(10) Transformer cable ratings require closer assessment.

Top Of This Section

Z/S - BELCONNEN - CONTINUOUS RATING

Contents - Zone Substation Information - Belconnen Zone Substation
- Two Hour Emergency Rating
- **Continuous Rating**
- Normal & Emergency Operation (ZSS Diagram)

EQUIPMENT CONTINUOUS RATING		TX 1	TX 2
TRANSFORMER	(MVA) (LV Amps)	**(1)** **55** **2885** (GEC)	**(1)** **55** **2885** (GEC)
OLTC	(HV Amps)	500	500
HV Bushings	(HV Amps)	1250	1250
LV Bushings	(Amps per 2 bushings)	4000	4000
TX Cables (Copper PILC)	(Summer/Winter) (LV Amps per Circuit) (Cable Size)	1660/2000 (630 mm^2)	1660/2000 (630 mm^2)
Group Busbar	(LV Amps) (Type)	2000 (Brush)	2000 (Brush)
Group Circuit Breakers and Bus-Coupler	(LV Amps)	2000 (Brush)	2000 (Brush)
ZONE CONTINUOUS RATING (MVA)		**(2)** **55/55** **Summer/Winter**	

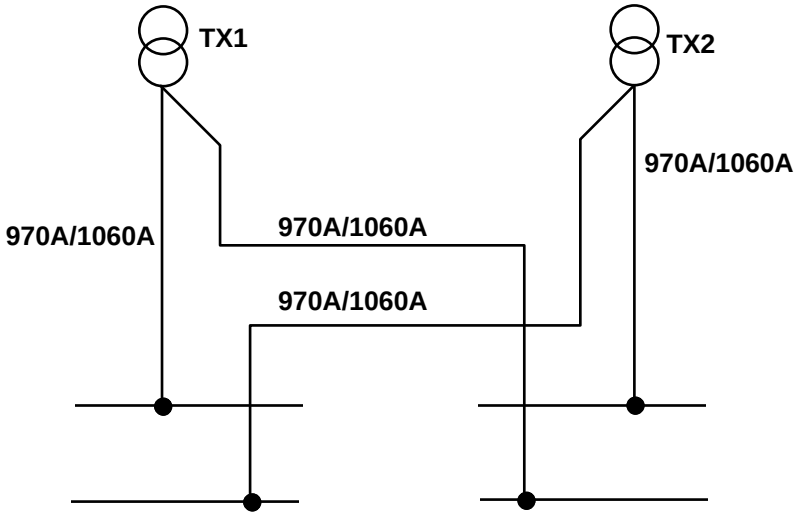
Notes:
(1) Summer and Winter limit
(2) Maximum continuous rating
(3) Note that the continuous rating for some equipment (OLTC, HV Bushings, LV Bushings, TX Cables, Group Busbar, Group CB's, and Bus-Coupler) is the same as the emergency rating.
(4) The CT's for transformer differential protection (on 11kV Group CB's) are rated at 1925 Amps. The small difference between this and the winter rating of the transformer cables is considered to have no effect on the emergency rating.
(5) Ratings below 100 A are given to the nearest 1 A, and ratings above 100 A are given to the nearest 5 A.
(6) Transformer cable ratings require closer assessment and confirmation.

Top Of This Section

Contents - Zone Substation Information - Belconnen Zone Substation
- Two Hour Emergency Rating
- Continuous Rating
- **Normal & Emergency Operation (ZSS Diagram)**

Normal Operation

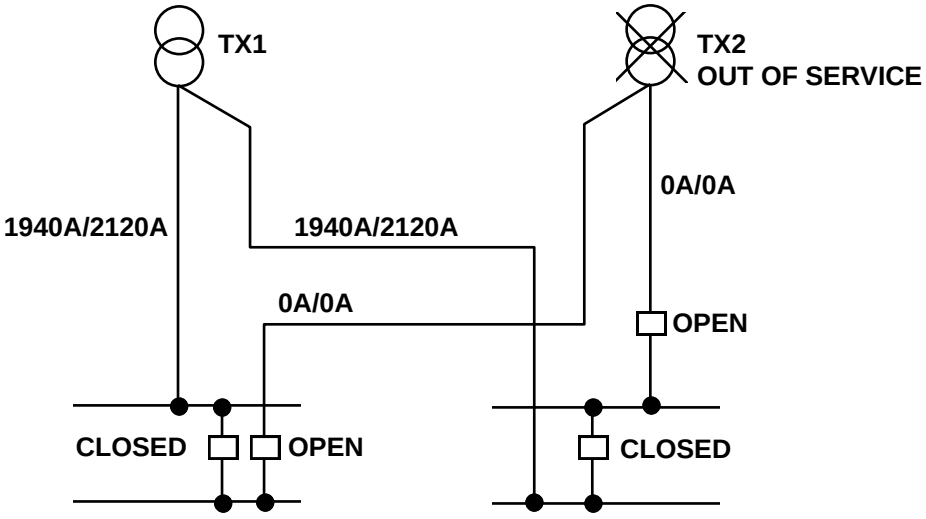
Summer/Winter LV Amps



Assuming the worst-case scenario of TX2 failing and the maximum allowable firm rating of each transformer is based on half of the emergency rating.

Emergency Operation

Summer/Winter LV Amps



Theoretically, the current in the transformer cables connected to TX1 under these fault conditions can be calculated to be:

970A/1060A
\+ 970A/1060A
1940A/2120A (Summer/Winter)

As this is above the maximum rating of the transformer cables (1660A/2000A), the emergency rating of the zone substation is therefore limited by the rating of the transformer cables.

Top Of This Section

CITY EAST ZONE SUBSTATION

Contents - Zone Substation Information - **City East Zone Substation**
- Two Hour Emergency Rating
- Continuous Rating
- Normal & Emergency Operation (ZSS Diagram)

Z/S - CITY EAST - TWO HOUR EMERGENCY RATING

Contents - Zone Substation Information - City East Zone Substation
- **Two Hour Emergency Rating**
- Continuous Rating
- Normal & Emergency Operation (ZSS Diagram)

EQUIPMENT "2 HOUR EMERGENCY" RATING			TX 1	TX 2	TX 3
TRANSFORMER		(Summer/Winter) (MVA) (LV Amps) (HV Amps)	 79/88 4145/4620 345/385 (Tyree)	 74/81 3885/4250 325/355 (GEC)	 78/87 4095/4565 340/380 (Tyree)
OLTC		(HV Amps)	500	500	500
HV Bushings		(HV Amps)	630	1250	630
LV Bushings	(4)	(Amps per 2 bushings) **(Summer/Winter)**	3200 **(1)/(2)**	4000 **(1)/(2)**	3200 **(1)/(2)**
TX Cables (Copper PILC)		(LV Amps per Circuit) (Cable Size)	**1660/2000** (630 mm^2)	**1660/2000** (630 mm^2)	**1660/2000** (630 mm^2)
Group Busbar		(LV Amps) (Type)	2000 (Brush)	2000 (Brush)	2000 (Brush)
Group Circuit Breakers and Bus-Coupler		(LV Amps)	2000 (Brush)	2000 (Brush)	2000 (GEC)
ZONE EMERGENCY RATING (MVA)				**(3) 95/114 Summer/Winter**	

Notes:
(1) Summer limit
(2) Winter limit
(3) Rating of the substation is limited by the rating of the transformer cables, i.e. 95/114 MVA total (summer/winter).
(4) This is continuos rating. It has been assumed that the 2 hour bushing rating is 25% above the continuous rating
(5) If the firm rating of each transformer is based on two thirds of the total emergency rating then in the event of a failure of any one transformer the theoretical minimum current in the two transformer cable circuits would be 2660/3030 Amps (summer/winter). Calculations are shown in Normal & Emergency Operation (ZSS Diagram). The emergency rating of the zone substation is therefore limited by the transformer cables.
(6) Note that the continuous rating for some equipment (OLTC, HV Bushings, LV Bushings, TX Cables, Group Busbar, Group CB's, and Bus-Coupler) is the same as the emergency rating.
(7) The CT's for transformer differential protection (on 11kV Group CB's) are rated at 1925 Amps.
(8) The small difference between this and the winter rating of the transformer cables is considered to have no effect on the emergency rating.
(9) Ratings below 100 A are given to the nearest 1 A, and ratings above 100 A are given to the nearest 5 A.
(10) Transformer cable ratings require closer assessment and confirmation

Top Of This Section

Z/S - CITY EAST - CONTINUOUS RATING

Contents - Zone Substation Information - City East Zone Substation
- Two Hour Emergency Rating
- **Continuous Rating**
- Normal & Emergency Operation (ZSS Diagram)

EQUIPMENT CONTINUOUS RATING		TX 1	TX 2	TX 3
TRANSFORMER	(MVA) (LV Amps)	**(2)** **57** **2990** (Tyree)	**(2)** **55** **2885** (GEC)	**(2)** **57** **2990** (Tyree)
OLTC	(HV Amps)	500	500	500
HV Bushings	(HV Amps)	630	1250	630
LV Bushings	(Amps per 2 bushings)	3200	4000	3200
TX Cables (Copper PILC)	(**Summer**/Winter) (LV Amps per Circuit) (Cable Size)	**(1)** **1660**/2000 (630 mm^2)	**(1)** **1660**/2000 (630 mm^2)	**(1)** **1660**/2000 (630 mm^2)
Group Busbar	(LV Amps) (Type)	2000 (Brush)	2000 (Brush)	2000 (Brush)
Group Circuit Breakers and Bus-Coupler	(LV Amps)	2000 (Brush)	2000 (Brush)	2000 (GEC)
ZONE CONTINUOUS RATING (MVA)			**(3)** **95/112** **Summer/Winter**	

Notes:
(1) Summer limit
(2) Winter limit
(3) Maximum continuous rating
(4) Note that the continuous rating for some equipment (OLTC, HV Bushings, LV Bushings, TX Cables, Group Busbar, Group CB's, and Bus-Coupler) is the same as the emergency rating.
(5) The CT's for transformer differential protection (on 11kV Group CB's) are rated at 1925 Amps. The small difference between this and the winter rating of the transformer cables is considered to have no effect on the emergency rating.
(6) Ratings below 100 A are given to the nearest 1 A, and ratings above 100 A are given to the nearest 5 A.
(7) Transformer cable ratings require closer assessment and confirmation.

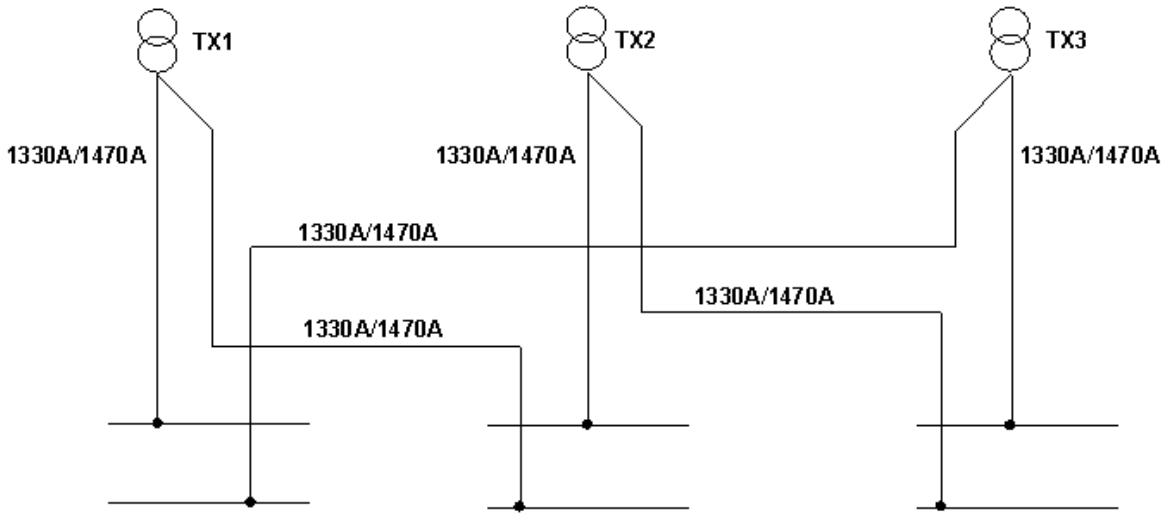
Top Of This Section

Z/S - CITY EAST - NORMAL & EMERGENCY OPERATION (ZSS DIAGRAM)

Contents - Zone Substation Information - City East Zone Substation
- Two Hour Emergency Rating
- Continuous Rating
- **Normal & Emergency Operation (ZSS Diagram)**

Normal Operation

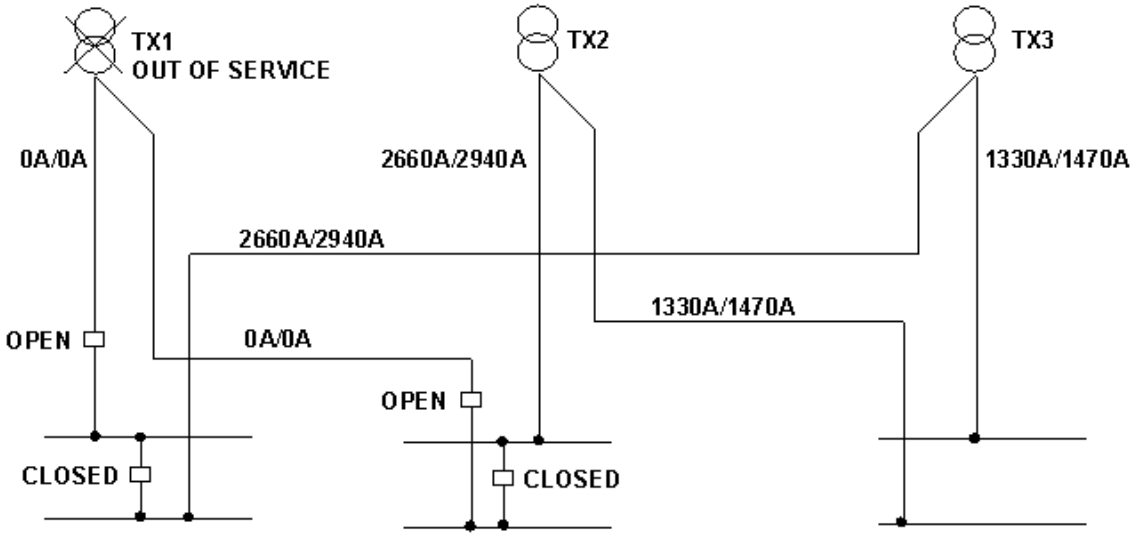
Summer/Winter LV Amps



Assuming the worst case scenario of TX1 failing and the maximum allowable firm rating of each transformer is based on two thirds of the emergency rating.

Emergency Operation

Summer/Winter LV Amps



Theoretically, the current in each of the transformer cables connected to TX2 and TX3 under these fault conditions can be calculated to be:

Cable 1. 1330A/1470A
+ 1330A/1470A
2660A/2940A (Summer/Winter)

Cable 2. 1330A/1470A (Summer/Winter)

Cable 1 is defined as the cable connected to the busbar previously supplied from the transformer out of service.

As the currents in Cable 1 are above the maximum rating of the transformer cables (1660A/2000A), the emergency rating of the zone substation is therefore limited by the rating of the transformer cables.

Top Of This Section

CIVIC ZONE SUBSTATION – UPDATED APRIL 2013

Contents - Zone Substation Information - **Civic Zone Substation**
- Two Hour Emergency Rating
- Continuous Rating
- Normal & Emergency Operation (ZSS Diagram)

Z/S - CIVIC - TWO HOUR EMERGENCY RATING

Contents - Zone Substation Information - Civic Zone Substation
- **Two Hour Emergency Rating**
- Continuous Rating
- Normal & Emergency Operation (ZSS Diagram)

EQUIPMENT "2 HOUR EMERGENCY" RATING		TX 1	TX 2	TX 3
TRANSFORMER	(Summer/Winter) (MVA) (LV Amps) (HV Amps)	 74/81 3885/4250 325/355 (GEC)	 78/86 4095/4515 340/375 (GEC)	 72/77 3780/4040 315/335 (ABB)
OLTC	(HV Amps)	500	500	600
HV Bushings	(HV Amps)	1250	1250	1250
LV Bushings (4) TX1 & Tx2 ONLY)	(Amps per 2 bushings –	4000	4000	2500
TX Cables (Copper PILC)	(**Summer**/Winter) (LV Amps per Circuit) (Cable Size)	(1) **2000**/2900 (800mm^2 Cu)	(1) **2000**/2900 (800mm^2 Cu)	(1) **2000**/2900 (800mm^2 Cu)
Group Busbar	(LV Amps) (Type)	(2) 2500 (ABB ZS1)	(2) 2500 (ABB ZS1)	(2) 2500 (ABB ZS1)
Group Circuit Breakers and Bus-Coupler	(LV Amps)	(2) **2500** (ABB ZS1)	(2) **2500** (ABB ZS1)	(2) **2500** (ABB ZS1)
ZONE EMERGENCY RATING (MVA)			(3) **114/143** **Summer/Winter**	

Notes:
(7) Summer limit
(8) Winter limit
(9) Rating of the substation is limited by the rating of the transformer cables in summer and the group CB's/switchboard busbars in winter. i.e. Emergency rating of the zone substation is 114/143 MVA total (summer/winter).
(10) This is a continuos rating. It has been assumed that the 2 hour bushing rating is 25% above the continuous rating.
(11) If the firm rating of each transformer is based on two thirds of the total emergency rating then in the event of a failure of any one transformer the current in two of the transformer cable circuits would be 2520A/2690 Amps (summer/winter). Calculations are shown in Normal & Emergency Operation (ZSS Diagram). The emergency rating of the zone substation is therefore limited by the transformer cables in summer and the Group Busbar, Group Circuit Breakers and Bus-Coupler in winter. (2000A/2500A)

Note that the continuous rating for some equipment (OLTC, HV Bushings, LV Bushings, TX Cables, Group Busbar, Group CB's, and Bus-Coupler) is the same as the emergency rating.
(12) Ratings below 100 A are given to the nearest 1 A, and ratings above 100 A are given to the nearest 5 A.
(13) Transformer cable ratings require closer assessment and confirmation

Top Of This Section

Z/S - CIVIC - CONTINUOUS RATING

Contents - Zone Substation Information - Civic Zone Substation
- Two Hour Emergency Rating
- **Continuous Rating**
- Normal & Emergency Operation (ZSS Diagram)

EQUIPMENT CONTINUOUS RATING		TX 1	TX 2	TX 3
TRANSFORMER	(MVA) (LV Amps)	**(1)** **55** **2885** (GEC)	**(1)** **55** **2885** (GEC)	**(1)** **55** **2885** (ABB)
OLTC	(HV Amps)	500	500	600
HV Bushings	(HV Amps)	1250	1250	1250
LV Bushings TX1 & Tx2 ONLY)	(Amps per 2 bushings –	4000	4000	2500
TX Cables (Copper PILC)	(Summer/Winter) (LV Amps per Circuit) (Cable Size)	(1) **2000**/2900 (800mm^2 Cu)	(1) **2000**/2900 (800mm^2 Cu)	(1) **2000**/2900 (800mm^2 Cu)
Group Busbar	(LV Amps) (Type)	2500 (ABB ZS1)	2500 (ABB ZS1)	2500 (ABB ZS1)
Group Circuit Breakers and Bus-Coupler	(LT Amps)	2500 (ABB ZS1)	2500 (ABB ZS1)	2500 (ABB ZS1)
ZONE CONTINUOUS RATING (MVA)			**(1)** **110/110** **Summer/Winter**	

Notes:
(6) Summer and Winter limit
(7) Maximum continuous rating
(8) Note that the continuous rating for some equipment (OLTC, HV Bushings, LV Bushings, TX Cables, Group Busbar, Group CB's, and Bus-Coupler) is the same as the emergency rating.
(9) Ratings below 100 A are given to the nearest 1 A, and ratings above 100 A are given to the nearest 5 A.
(10) Transformer cable ratings require closer assessment and confirmation

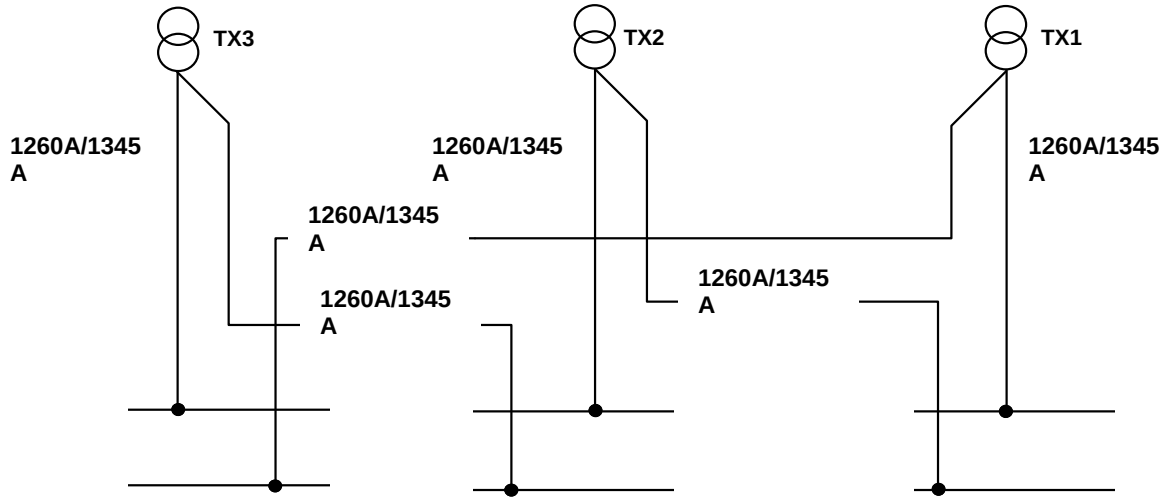
Top Of This Section

Z/S - CIVIC - NORMAL & EMERGENCY OPERATION (ZSS DIAGRAM)

Contents - Zone Substation Information - Civic Zone Substation
- Two Hour Emergency Rating
- Continuous Rating
- **Normal & Emergency Operation (ZSS Diagram)**

Normal Operation

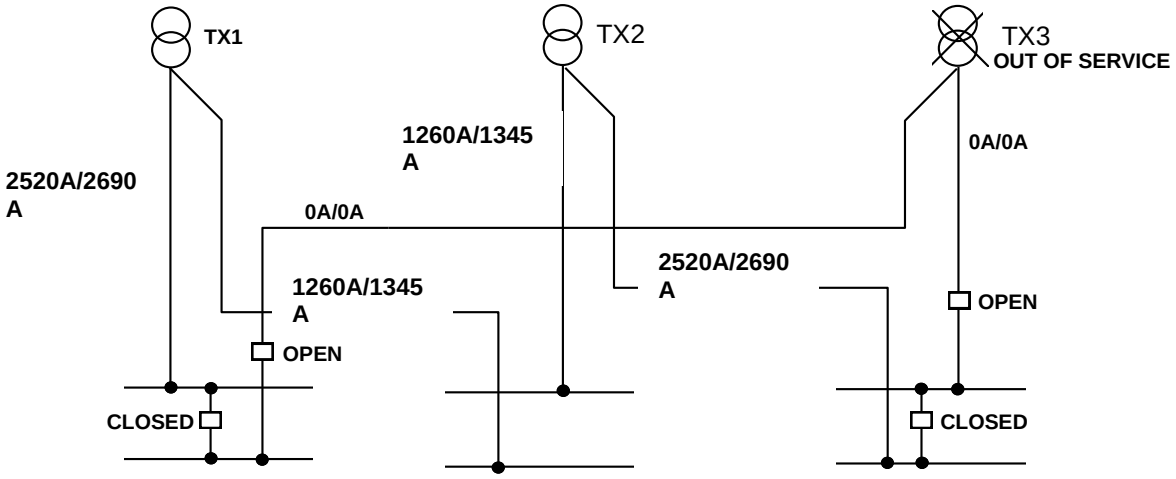
Summer/Winter LV Amps



Assuming the worst case scenario of TX2 failing and the maximum allowable firm rating of each transformer is based on half of the emergency rating.

Emergency Operation

Summer/Winter LV Amps



Theoretically, the current in the transformer cables connected to TX1 and TX3 under these fault conditions can be calculated to be:

Cable 1. 1260A/1345A

Cable 2: 1260A/1345A

\+ 1260A/1345A

2520A/2690A (Summer/Winter)

Cable 1 is defined as the cable connected to the busbar previously supplied from the transformer out of service. The emergency rating of the zone substation is therefore limited by the transformer cables in summer and the group CB in winter (2000/2500).

FYSHWICK ZONE SUBSTATION

Contents - Zone Substation Information - **Fyshwick Zone Substation**
- Two Hour Emergency Rating

- Continuous Rating
- Normal & Emergency Operation (ZSS Diagram)

Z/S - FYSHWICK - TWO HOUR EMERGENCY RATINGS

Contents - Zone Substation Information - Fyshwick Zone Substation

- **Two Hour Emergency Rating**
- Continuous Rating
- Normal & Emergency Operation (ZSS Diagram)

EQUIPMENT "2 HOUR EMERGENCY" RATING		TX 1	TX 2	TX 3
	(Summer/Winter)			
TRANSFORMER	(MVA)	26.2/29.9 (ONAF)	30/30 (10)	34/39
	(LV Amps)	1375/1570	1575/1575	1785/2045
		(ABB)	(Wilson)	(Tyree)
OLTC	(HV Amps)	300	300	200
HV Bushings	(HV Amps)	800	800	400
HV Differential Protection				
CT 66kV	(HV Amps)	**125**	**125**	**125 (3)**
LV Bushings	(Amps per bushing)	2000 (1)	2000 (1)	1200 (1) (4) (5)
TX Cables	(LV Amps per Circuit)	1220 (2)	1220 (2)	1220 (2)
	(Cable Size)	(630 mm^2)	(630 mm^2)	(630 mm^2)
Group Busbar	(LV Amps)	2000	2000	2000
Group Circuit Breakers and		2000	2000	2000
Bus-Coupler	(LV Amps)	(Hawker Siddeley)	(Hawker Siddeley)	(Hawker Siddeley)
ZONE EMERGENCY RATING (MVA)			**28/28 Summer/Winter (3)**	

Figures in **bold** are factors that limit the ratings of each transformer and associated equipment.

Notes:

(1) Summer and Winter limit

(2) These ratings are based on 12.7/22 kV Single Core XLPE Cable, as found on page 6 of OLEX Cables Catalogue. These values are based on cables in trefoil formation in a duct. Under ground temperature, depth, etc. is to be confirmed. Summer / winter de-rating factors are to be confirmed. Since there are two trefoil groups of cables per circuit, the value quoted in OLEX Cables, 610 A, is doubled to 1220 Amps.

(3) Emergency rating of the substation is limited by the rating of the 66kV HV differential protection CT as advised in ENAN No. 12527 dated 27/6/13.

(4) Short term 2 hour rating 2000 A. Specified by Siemens in fax dated 31/5/2001.

(5) TX load theoretical calculations are shown in Normal & Emergency Operation (ZSS Diagram).

(6) Note that the continuous rating for some equipment (OLTC, HV Bushings, LV Bushings, TX Cables, Group Busbar, Group CB's, and Bus-Coupler) is the same as the emergency rating.

(7) The CT's for transformer differential protection (on 11kV Group CB's) are rated at 800 Amps. The small difference between this and the rating of the LV Bushings is considered to have no effect on the emergency rating

(8) Ratings below 100 A are given to the nearest 1 A, and ratings above 100 A are given to the nearest 5 A.

(9) Transformer cable ratings require closer assessment and confirmation.

(10) No factory test results were available to determine the 2-hour emergency rating of TX2. The assumed value is 20% higher than the continuous rating.

Top Of This Section

Z/S - FYSHWICK - CONTINUOUS RATING

Contents - Zone Substation Information - Fyshwick Zone Substation
- Two Hour Emergency Rating
- **Continuous Rating**
- Normal & Emergency Operation (ZSS Diagram)

EQUIPMENT CONTINUOUS RATING		**TX 1**	**TX 2**	**TX 3**
TRANSFORMER	(MVA)	21.7 (ONAF)(9)	25 (ODAN)	20
	(LV Amps)	1140	1312	1050
		(ABB)	(Wilson)	(Tyree)
OLTC	(HV Amps)	300	300	200
HV Bushings	(HV Amps)	800	800	400
HV Differential Protection CT 66kV	(HV Amps)	**125**	**125**	**125 (3)**
LV Bushings	(Amps per bushing)	2000 (1)	2000 (1)	1200 (1) (4)
TX Cables	(LV Amps per Circuit)	1220 (2)	1220 (2)	1220 (2)
	(Cable Size)	(630 mm^2)	(630 mm^2)	(630 mm^2)
Group Busbar	(LV Amps)	2000	2000	2000
Group Circuit Breakers and Bus-Coupler	(LV Amps)	2000 (Hawker Siddeley)	2000 (Hawker Siddeley)	2000 (Hawker Siddeley)
ZONE CONTINUOUS RATING (MVA)			**28/28 Summer/Winter (3)**	

Figures in **bold** are factors that limit the ratings of each transformer and associated equipment.

Notes:

(1) Summer and Winter limit

(2) These ratings are based on 12.7/22 kV Single Core XLPE Cable, as found on page 6 of OLEX Cables Catalogue. These values are based on cables in trefoil formation in a duct. Under ground temperature, depth, etc. is to be confirmed. Summer / winter de-rating factors are to be confirmed. Since there are two trefoil groups of cables per circuit, the value quoted in OLEX Cables, 610 A, is doubled to 1220 Amps.

(3) Continuous rating of the substation is limited by the 66kV HV differential protection CT as advised in ENAN No. 12527 dated 27/6/13.

(4) Short term 2 hour bushing rating is 2000 A. Specified by Siemens in fax to ActewAGL dated 31/5/2001.

(5) Note that the continuous rating for some equipment (OLTC, HV Bushings, LV Bushings, TX Cables, Group Busbar, Group CB's, and Bus-Coupler) is the same as the emergency rating.

(6) The CT's for transformer differential protection (on 11kV Group CB's) are rated at 800 Amps. The small difference between this and the rating of the LV Bushings is considered to have no effect on the emergency rating

(7) Ratings below 100 A are given to the nearest 1 A, and ratings above 100 A are given to the nearest 5 A.

(8) Transformer cable ratings require closer assessment and confirmation.

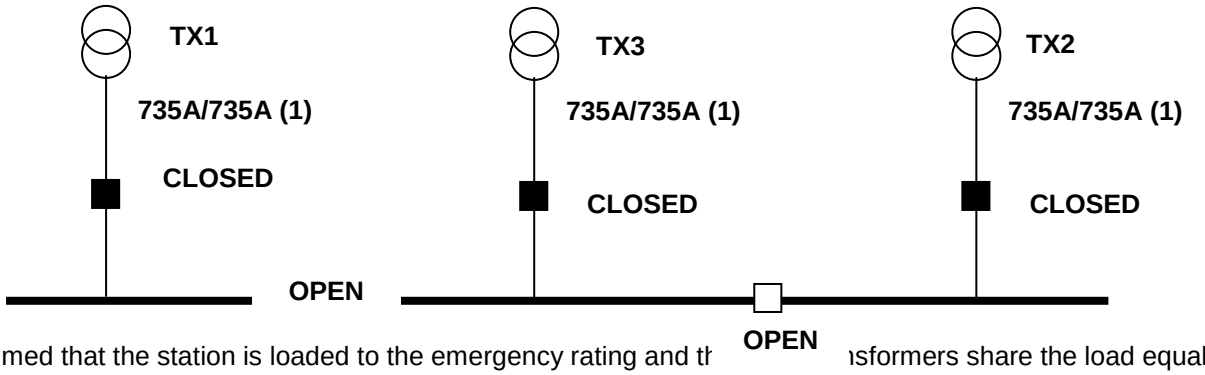
(9) Analysis of manufacturer test reports indicates 16.8/21.7MVA ONAN/ONAF rating which is higher than nameplate value.

Top Of This Section

Contents - Zone Substation Information - Fyshwick Zone Substation
- Two Hour Emergency Rating
- Continuous Rating
- **Normal & Emergency Operation (ZSS Diagram)**

Maximum Load Normal Operation

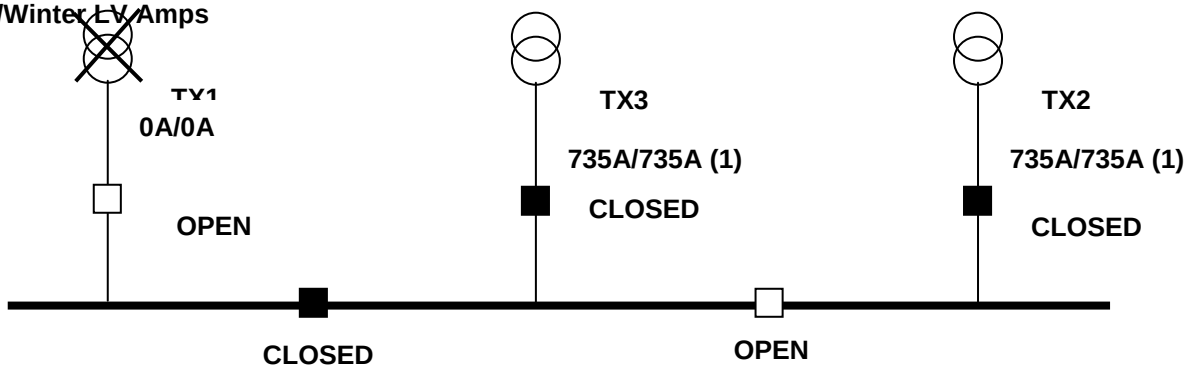
Summer/Winter LV Amps



It is assumed that the station is loaded to the emergency rating and tr ısformers share the load equally. Loss of TX1 (or TX2) or associated equipment is the worst-case scenario. The theoretical current in TX2 and TX3 under the worst case is shown below.

Maximum Load Emergency Operation

Summer/Winter LV Amps



It is assumed that transformer load can be balanced by load transfer through the feeder ties.

Notes:

1) **The rating of the substation is limited by the 66kV HV Differential Protection CT resulting in LV load of 735A(14MVA) as advised in the ENAN No. 12527 dated 27/6/13.**

Top Of This Section

GILMORE ZONE SUBSTATION

Contents - Zone Substation Information - **Gilmore Zone Substation**
- Two Hour Emergency Rating
- Continuous Rating
- Normal & Emergency Operation (ZSS Diagram)

Z/S - GILMORE - TWO HOUR EMERGENCY RATING

Contents - Zone Substation Information - Gilmore Zone Substation
- **Two Hour Emergency Rating**
- Continuous Rating
- Normal & Emergency Operation (ZSS Diagram)

EQUIPMENT "2 HOUR EMERGENCY" RATING			TX 1	TX 3
TRANSFORMER		(**Summer/Winter**) (MVA) (LV Amps) (HV Amps)	**(1)/(2)** **62/69** **3255/3620** 270/300	**(1)/(2)** **62/69** **3255/3620** 270/300
			(Tyree)	(Tyree)
OLTC		(HV Amps)	400	400
HV Bushings		(HV Amps)	630	630
LV Bushings	(4)	(Amps per 2 bushings)	3200	3200
		(Summer/Winter)		
TX Cables		(LV Amps per Circuit)	1660/2000	1660/2000
(Copper PILC)	(Cable Size)		(630 mm^2)	(630 mm^2)
Group Busbar		(LV Amps)	2000	2000
		(Type)	(Brush)	(Brush)
Group Circuit Breakers and Bus-Coupler		(LV Amps)	2000 (GEC.)	2000 (GEC.)
ZONE EMERGENCY RATING (MVA)			**(3)** **62/69** **Summer/Winter**	

Notes:
(1) Summer limit
(2) Winter limit
(3) Rating of the substation is limited by the emergency rating of one transformer, i.e. 62/69 MVA total (summer/winter).
(4) This is a continuos rating. It has been assumed that the 2 hour bushing rating is 25% above the continuous rating
(5) If the maximum allowable firm rating of each transformer is based on half of the emergency rating then in the event of a failure of any one transformer the current in the transformer cables would be 1630/1810 Amps (summer/winter). Calculations are shown in Normal & Emergency Operation (ZSS Diagram). The emergency rating of the zone substation is therefore limited by the rating of the transformers.
(6) Note that the continuous rating for some equipment (OLTC, HV Bushings, LV Bushings, TX Cables, Group Busbar, Group CB's, and Bus-Coupler) is the same as the emergency rating.
(7) Ratings below 100 A are given to the nearest 1 A, and ratings above 100 A are given to the nearest 5 A.
(8) Transformer cable ratings require closer assessment and confirmation.

Top Of This Section

Z/S - GILMORE - CONTINUOUS RATING

Contents - Zone Substation Information - Gilmore Zone Substation
- Two Hour Emergency Rating
- **Continuous Rating**
- Normal & Emergency Operation (ZSS Diagram)

EQUIPMENT CONTINUOUS RATING		TX 1	TX 3
TRANSFORMER	(MVA) (LV Amps)	**(1)** **45** **2360** (Tyree)	**(1)** **45** **2360** (Tyree)
OLTC	(HV Amps)	400	400
HV Bushings	(HV Amps)	630	630
LV Bushings	(Amps per 2 bushings)	3200	3200
TX Cables (Copper PILC)	(Summer/Winter) (LV Amps per Circuit) (Cable Size)	1660/2000 (630 mm^2)	1660/2000 (630 mm^2)
Group Busbar	(LV Amps) (Type)	2000 (Brush)	2000 (Brush)
Group Circuit Breakers and Bus-Coupler	(LV Amps)	2000 (GEC.)	2000 (GEC.)
ZONE CONTINUOUS RATING (MVA)		**(2)** **45/45** **Summer/Winter**	

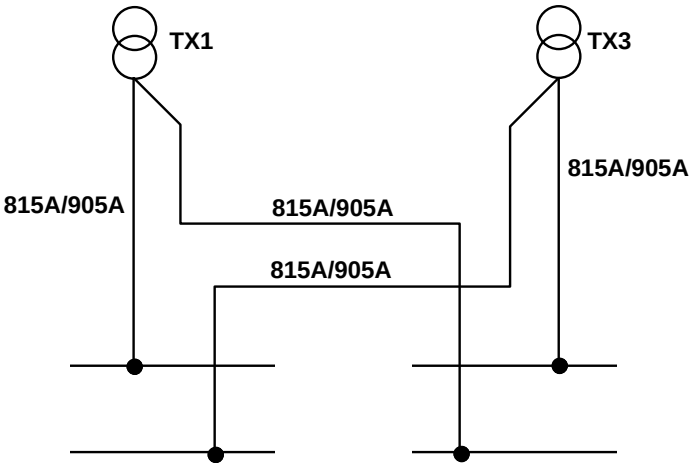
Notes:
(1) Summer and winter limit
(2) Maximum continuous rating
(3) Note that the continuous rating for some equipment (OLTC, HV Bushings, LV Bushings, TX Cables, Group Busbar, Group CB's, and Bus-Coupler) is the same as the emergency rating.
(4) Ratings below 100 A are given to the nearest 1 A, and ratings above 100 A are given to the nearest 5 A.
(5) Transformer cable ratings require closer assessment and confirmation.

Top Of This Section

Contents - Zone Substation Information - Gilmore Zone Substation
- Two Hour Emergency Rating
- Continuous Rating
- **Normal & Emergency Operation (ZSS Diagram)**

Normal Operation

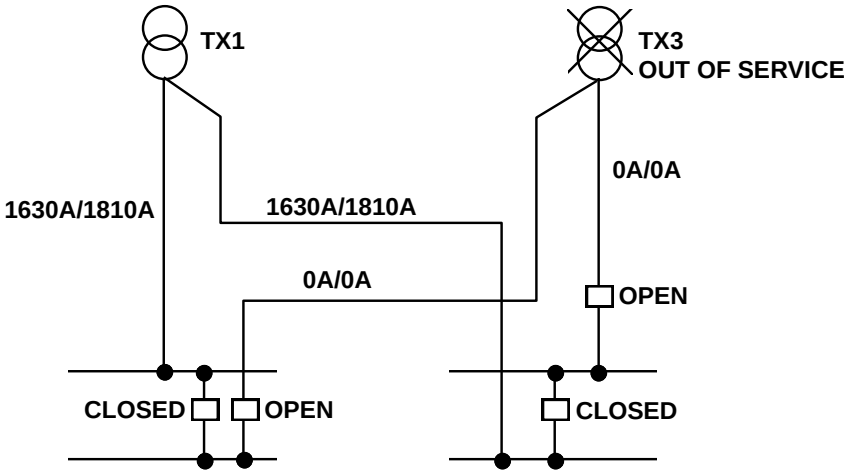
Summer/Winter LV Amps



Assuming the worst case scenario of TX3 failing and the maximum allowable firm rating of each transformer is based on half of the emergency rating.

Emergency Operation

Summer/Winter LV Amps



Theoretically, the current in each of the transformer cables connected to TX1 under these fault conditions can be calculated to be:

	815A/ 905A
+	815A/ 905A
	1630A/1810A

Since these limits are lower than the limits for the other components in the zone substation (cables, busbars, etc.), the emergency rating of the zone substation is limited by the rating of the transformers.

Top Of This Section

GOLD CREEK ZONE SUBSTATION

Contents - Zone Substation Information - **Gold Creek Zone Substation**
- Two Hour Emergency Rating
- Continuous Rating
- Normal & Emergency Operation (ZSS Diagram)

Z/S - GOLD CREEK - TWO HOUR EMERGENCY RATING

Contents - Zone Substation Information - Gold Creek Zone Substation
- **Two Hour Emergency Rating**
- Continuous Rating
- Normal & Emergency Operation (ZSS Diagram)

EQUIPMENT "2 HOUR EMERGENCY" RATING			TX 1	TX 3
TRANSFORMER		(**Summer/Winter**) (MVA) (LV Amps) (HV Amps)	**(1)/(2)** 74/84 3885/4410 325/365 (Wilsons)	**(1)/(2)** 77/85 4040/4460 335/370 (Wilsons)
OLTC		(HV Amps)	500	500
HV Bushings		(HV Amps)	1250	1250
LV Bushings	(4)	(Amps per 2 bushings)	3600	3600
TX Cables (Copper XLPE)		(Summer/Winter) (LV Amps per Circuit) (Cable Size)	(1)/(2) 2000/2900 (800 mm^2)	(1)/(2) 2000/2900 (800 mm^2)
Group Busbar		(LV Amps) (Type)	**2000** (GEC Alsthom)	**2000** (GEC Alsthom)
Group Circuit Breakers and Bus-Coupler		(LV Amps) (Manufacturer)	2500 (GEC Alsthom)	2500 (GEC Alsthom)
ZONE EMERGENCY RATING (MVA)			**(3) 76/76 Summer/Winter**	

Notes:
(1) Summer limit
(2) Winter limit
(3) Rating of the substation is limited by the emergency rating of one transformer, i.e. 76/76 MVA total (summer/winter).
(4) This is a continuous rating. It has been assumed that the 2 hour bushing rating is 25% above the continuous rating
(5) If the maximum allowable firm rating of each transformer is based on half of the emergency rating then in the event of a failure of any one transformer the current in the transformer cables would be 1940/2200 Amps (summer/winter). Calculations are shown in Normal & Emergency Operation (ZSS Diagram). The emergency rating of the zone substation is therefore limited by the rating of the Group Busbar.
(6) The continuous rating for some equipment (OLTC, HV Bushings, LV Bushings, TX Cables, Group Busbar, Group CB's, and Bus-Coupler) is the same as the emergency rating.
(7) Ratings below 100 A are given to the nearest 1 A, and ratings above 100 A are given to the nearest 5 A.
(8) Transformer cable ratings require closer assessment and confirmation.

Top Of This Section

Z/S - GOLD CREEK - CONTINUOUS RATING

Contents - Zone Substation Information - Gold Creek Zone Substation
- Two Hour Emergency Rating
- **Continuous Rating**
- Normal & Emergency Operation (ZSS Diagram)

EQUIPMENT CONTINUOUS RATING		TX 1	TX 3
TRANSFORMER	(MVA) (LV Amps)	**(1)** **57** 2990 (Wilsons)	**(1)** **57** 2990 (Wilsons)
OLTC	(HV Amps)	500	500
HV Bushings	(HV Amps)	1250	1250
LV Bushings	(Amps per 2 bushings)	3600	3600
TX Cables (Copper XLPE)	(Summer/Winter) (LV Amps per Circuit) (Cable Size)	2000/2900 (800 mm^2)	2000/2900 (800 mm^2)
Group Busbar	(LV Amps) (Type)	2000 (GEC Alsthom)	2000 (GEC Alsthom)
Group Circuit Breakers and Bus-Coupler	(LV Amps) (Manufacturer)	2500 (GEC Alsthom)	2500 (GEC Alsthom)
ZONE CONTINUOUS RATING (MVA)		**(2)** **57/57** **Summer/Winter**	

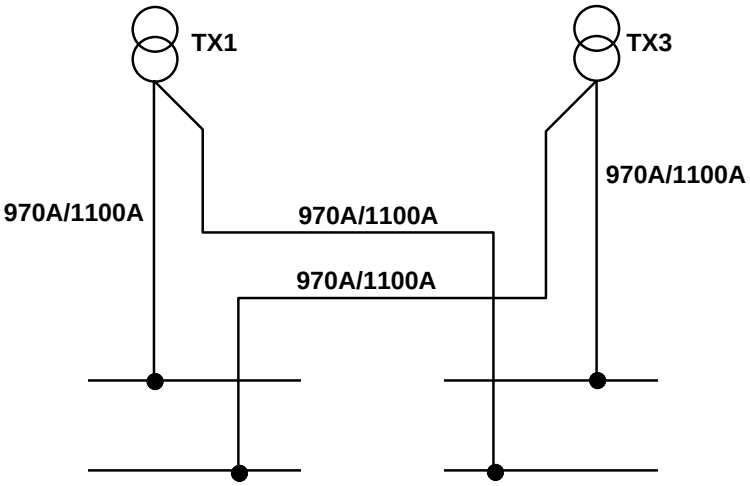
Notes:
(1) Summer and Winter Limit
(2) Maximum continuous rating
(3) Ratings below 100 A are given to the nearest 1 A, and ratings above 100 A are given to the nearest 5 A.
(4) Note that the continuous rating for some equipment (OLTC, HV Bushings, LV Bushings, TX Cables, Group Busbar, Group CB's, and Bus-Coupler) is the same as the emergency rating.
(5) Transformer cable ratings require closer assessment and confirmation.

Top Of This Section

Contents - Zone Substation Information - Gold Creek Zone Substation
- Two Hour Emergency Rating
- Continuous Rating
- **Normal & Emergency Operation (ZSS Diagram)**

Normal Operation

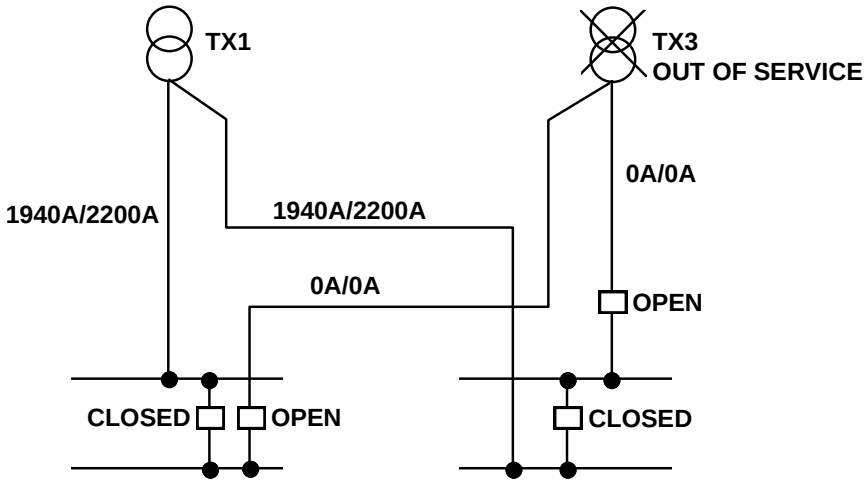
Summer/Winter LV Amps



Assuming the worst case scenario of TX3 failing and the maximum allowable firm rating of each transformer is based on half of the emergency rating.

Emergency Operation

Summer/Winter LV Amps



Theoretically, the current in each of the transformer cables connected to TX1 under these fault conditions can be calculated to be:

970A/ 1100A
\+ 970A/ 1100A
1940A/ 2200A

The emergency rating of the zone substation is therefore limited by the rating of the Group Busbar.

Top Of This Section

LATHAM ZONE SUBSTATION

Contents - Zone Substation Information - **Latham Zone Substation**
- Two Hour Emergency Rating
- Continuous Rating
- Normal & Emergency Operation (ZSS Diagram)

Z/S - LATHAM - TWO HOUR EMERGENCY RATING

Contents - Zone Substation Information - Latham Zone Substation
- **Two Hour Emergency Rating**
- Continuous Rating
- Normal & Emergency Operation (ZSS Diagram)

EQUIPMENT "2 HOUR EMERGENCY" RATING			TX 1	TX 2	TX 3
TRANSFORMER		(Summer/Winter) (MVA) (LV Amps) (HV Amps)	 73/81 3830/4250 320/355 (Tyree)	 71/78 3725/4095 310/340 (Tyree)	 71/78 3725/4095 310/340 (Tyree)
OLTC		(HV Amps)	500	400	400
HV Bushings		(HV Amps)	630	630	630
LV Bushings	(4)	(Amps per 2 bushings)	6000	3200	3200
TX Cables (Copper PILC)		**(Summer/Winter)** (LV Amps per Circuit) (Cable Size)	**(1)/(2)** **1660/2000** (630 mm^2)	**(1)** **1760**/2180 (1 in^2)	**(1)** **1760**/2180 (1 in^2)
Group Busbar		(LV Amps) (Type)	2000 (GEC/H.S.)	2000 (Email)	2000 (Email)
Group Circuit Breakers and Bus-Coupler		(LV Amps)	2000 (GEC/H.S.)	**2000 (2)** (Email)	**2000 (2)** (Email)
ZONE EMERGENCY RATING (MVA)			**95/114 Summer/Winter (3)**		

Notes:
(1) Summer limit
(2) Winter limit
(3) Rating of on the substation is limited by the rating of the transformer cables and group CB's, i.e. 95/114 MVA total (summer/winter).
(4) This is a continuos rating. It has been assumed that the 2 hour bushing rating is 25% above the continuous rating
(5) If the firm rating of each transformer is based on two thirds of the total emergency rating then in the event of a failure of any one transformer the current in two of the transformer cable circuits would be 2480A/2730 Amps (summer/winter). Calculations are shown in Normal & Emergency Operation (ZSS Diagram). The emergency rating of the zone substation is therefore limited by the transformer cables for TX1 (1660/2000).
(6) Note that the continuous rating for some equipment (OLTC, HV Bushings, LV Bushings, TX Cables, Group Busbar, Group CB's, and Bus-Coupler) is the same as the emergency rating.
The CT's for transformer differential protection (on 11kV Group CB's) are rated at 1925 Amps.
(7) The small difference between this and the winter rating of the transformer cables is considered to have no effect on the emergency rating.
(8) Ratings below 100 A are given to the nearest 1 A, and ratings above 100 A are given to the nearest 5 A.
(9) Transformer cable ratings require closer assessment and confirmation.

Top Of This Section

Z/S - LATHAM - CONTINUOUS RATING

Contents - Zone Substation Information - Latham Zone Substation
- Two Hour Emergency Rating
- **Continuous Rating**
- Normal & Emergency Operation (ZSS Diagram)

EQUIPMENT CONTINUOUS RATING		TX 1	TX 2	TX 3
TRANSFORMER	(MVA) (LV Amps)	**(2)** **50** **2625** (Tyree)	**(2)** **50** **2625** (Tyree)	**(2)** **50** **2625** (Tyree)
OLTC	(HV Amps)	500	400	400
HV Bushings	(HV Amps)	630	630	630
LV Bushings	(Amps per 2 bushings)	6000	3200	3200
TX Cables (Copper PILC)	**(Summer**/Winter) (LV Amps per Circuit) (Cable Size)	**(1)** **1660**/2000 (630 mm^2)	**(1)** **1760**/2180 (1 in^2)	**(1)** **1760**/2180 (1 in^2)
Group Busbar	(LV Amps) (Type)	2000 (GEC/H.S.)	2000 (Email)	2000 (Email)
Group Circuit Breakers and Bus-Coupler	(LV Amps)	2000 (GEC/H.S.)	2000 (Email)	2000 (Email)
ZONE CONTINUOUS RATING (MVA)			**(3)** **95/100** **Summer/Winter**	

Notes:
(1) Summer limit
(2) Winter limit
(3) Maximum continuous rating

- Note that the continuous rating for some equipment (OLTC, HV Bushings, LV Bushings, TX Cables, Group Busbar, Group CB's, and Bus-Coupler) is the same as the emergency rating.
- The CT's for transformer differential protection (on 11kV Group CB's) are rated at 1925 Amps.
  The small difference between this and the winter rating of the transformer cables is considered to have no effect on the emergency rating.
- Ratings below 100 A are given to the nearest 1 A, and ratings above 100 A are given to the nearest 5 A.
- Transformer cable ratings require closer assessment and confirmation.

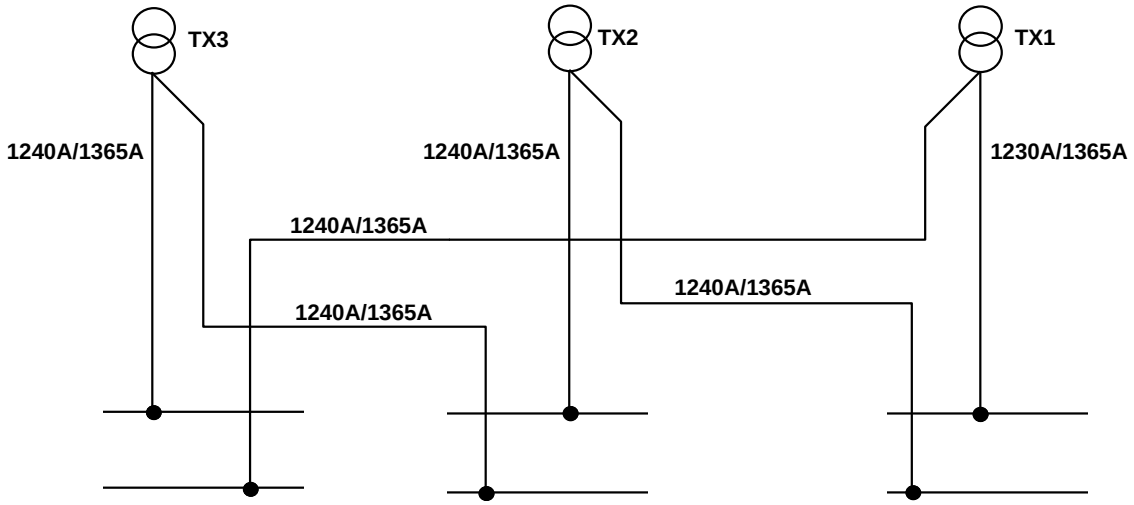
Top Of This Section

Z/S - LATHAM - NORMAL & EMERGENCY OPERATION (ZSS DIAGRAM)

Contents - Zone Substation Information - Latham Zone Substation
- Two Hour Emergency Rating
- Continuous Rating
- **Normal & Emergency Operation (ZSS Diagram)**

Normal Operation

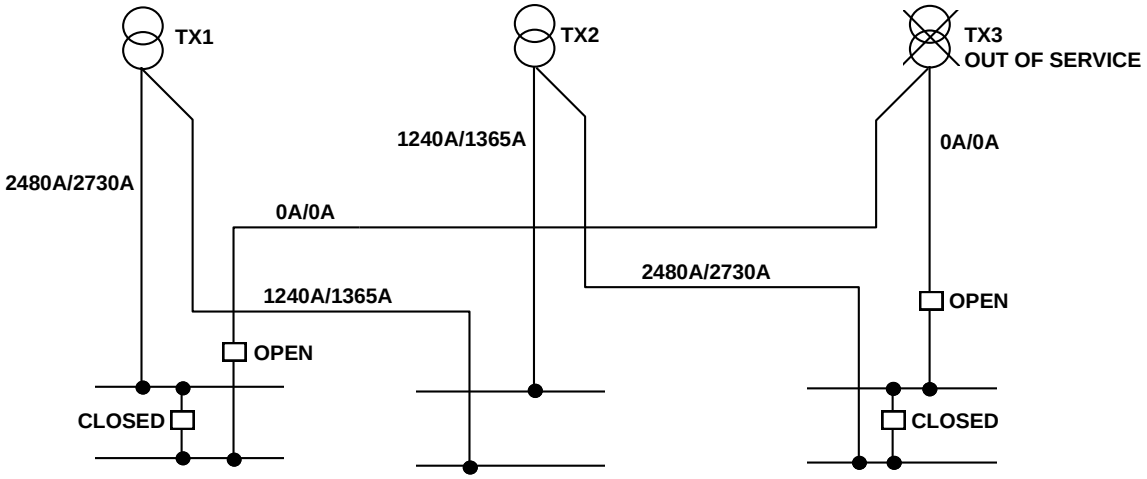
Summer/Winter LV Amps



Assuming the worst case scenario of TX3 failing and the maximum allowable firm rating of each transformer is based on two thirds of the emergency rating.

Emergency Operation

Summer/Winter LV Amps



Theoretically, the current in each of the transformer cables connected to TX2 and TX3 under these fault conditions can be calculated to be:

Cable 1. 1240A/1365A

Cable 2: 1240A/1365A

\+ 1240A/1365A

2480A/2730A (Summer/Winter)

Cable 1 is defined as the cable connected to the busbar previously supplied from the transformer out of service. The emergency rating of the zone substation is therefore limited by the transformer cables for TX1 (1660/2000).

Top Of This Section

TELOPEA PARK ZONE SUBSTATION

Contents - Zone Substation Information - **Telopea Park Zone Substation**
- Two Hour Emergency Rating
- Continuous Rating
- Normal & Emergency Operation (ZSS Diagram)

Z/S - TELOPEA PARK - TWO HOUR EMERGENCY RATING

Contents - Zone Substation Information - Telopea Park Zone Substation
- **Two Hour Emergency Rating**
- Continuous Rating
- Normal & Emergency Operation (ZSS Diagram)

EQUIPMENT "2 HOUR EMERGENCY" RATING			TX 1	TX 2	TX 3
TRANSFORMER		(Summer/Winter) (MVA) (LV Amps) (HV Amps)	 70/78 3675/4095 305/340 (Tyree)	 73/80 3830/4200 320/350 (Tyree)	 74/82 3885/4305 325/360 (Tyree)
OLTC		(HV Amps)	500	500	500
HV Bushings		(HV Amps)	1250	1250	630
LV Bushings	(4)	(Amps per 2 bushings)	6000	6000	6000
TX Cables (Copper XLPE)		**(Summer/Winter)** (LV Amps per Circuit) (Cable Size)	**(1)/(2)** **2300/2800** (800 mm^2)	**(1)/(2)** **2300/2800** (800 mm^2)	**(1)/(2)** **2300/2800** (800 mm^2)
Group Busbar		(LV Amps) (Type)	2000 (GEC)	2000 (GEC)	2000 (GEC)
Group Circuit Breakers and Bus-Coupler		(LV Amps)	2000 (GEC)	2000 (GEC)	2000 (GEC)
ZONE EMERGENCY RATING (MVA)				**114/114(3) Summer/Winter**	

Notes:
(1) Summer limit
(2) Winter limit
(3) Rating of the substation is limited by the rating of the Group Busbar, Group CB's and Bus-Coupler, i.e. 114/114 MVA total (summer/winter).
(4) This is a continuous rating. It has been assumed that the 2 hour bushing rating is 25% above the continuous rating
(5) If the firm rating of each transformer is based on two thirds of the total emergency rating then in the event of a failure of any one transformer the current in two transformer circuits would be 2500/2760 Amps (summer/winter). Calculations are shown in Normal & Emergency Operation (ZSS Diagram). The emergency rating of the zone substation is therefore limited by the Group Busbar, Group CB's and Bus-Coupler.
(6) Note that the continuous rating for some equipment (OLTC, HV Bushings, LV Bushings, TX Cables, Group Busbar, Group CB's, and Bus-Coupler) is the same as the emergency rating.
The CT's for transformer differential protection (on 11kV Group CB's) are rated at 1925 Amps.
The small difference between this and the winter rating of the Group Busbar and CB's is considered to have no effect on the emergency rating.
(7) Ratings below 100 A are given to the nearest 1 A, and ratings above 100 A are given to the nearest 5 A.
(8) Transformer cable ratings require closer assessment and confirmation.

Top Of This Section

Z/S - TELOPEA PARK - CONTINUOUS RATING

Contents - Zone Substation Information - Telopea Park Zone Substation
- Two Hour Emergency Rating
- **Continuous Rating**
- Normal & Emergency Operation (ZSS Diagram)

EQUIPMENT CONTINUOUS RATING		TX 1	TX 2	TX 3
TRANSFORMER	(MVA) (LV Amps)	**(2)** **50** **2625** (Tyree)	**(2)** **50** **2625** (Tyree)	**(2)** **50** **2625** (Tyree)
OLTC	(HV Amps)	500	500	500
HV Bushings	(HV Amps)	1250	1250	630
LV Bushings	(Amps per 2 bushings)	6000	6000	6000
TX Cables (Copper XLPE)	**(Summer**/Winter) (LV Amps per Circuit) (Cable Size)	**(1)** **2300/2800** (800 mm^2)	**(1)** **2300/2800** (800 mm^2)	**(1)** **2300/2800** (800 mm^2)
Group Busbar	(LV Amps) (Type)	2000 (GEC)	2000 (GEC)	2000 (GEC)
Group Circuit Breakers and Bus-Coupler	(LV Amps)	2000 (GEC)	2000 (GEC)	2000 (GEC)
ZONE CONTINUOUS RATING (MVA)			**(3)** **100/100** **Summer/Winter**	

Notes:
(1) Summer limit
(2) Winter limit
(3) Maximum continuous rating
(4) Note that the continuous rating for some equipment (OLTC, HV Bushings, LV Bushings, TX Cables, Group Busbar, Group CB's, and Bus-Coupler) is the same as the emergency rating.
(5) Ratings below 100 A are given to the nearest 1 A, and ratings above 100 A are given to the nearest 5 A.
(6) Transformer cable ratings require closer assessment and confirmation.

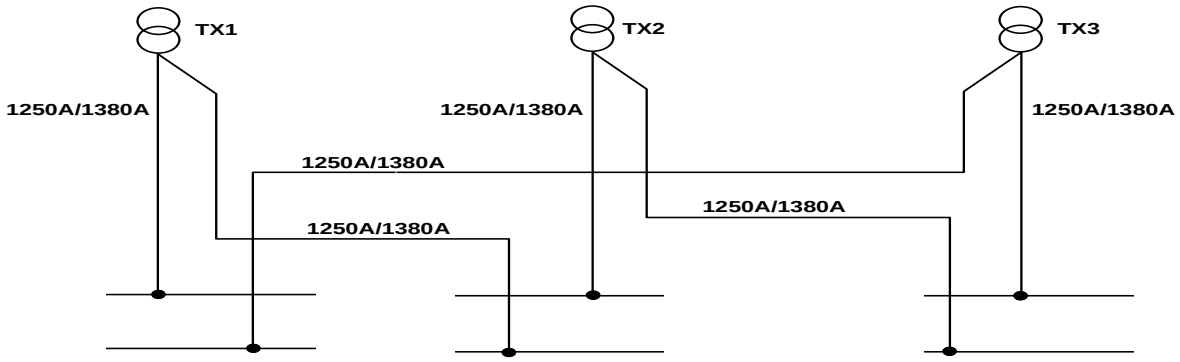
Top Of This Section

Z/S - TELOPEA PARK - NORMAL & EMERGENCY OPERATION (ZSS DIAGRAM)

Contents - Zone Substation Information - Telopea Park Zone Substation
- Two Hour Emergency Rating
- Continuous Rating
- **Normal & Emergency Operation (ZSS Diagram)**

Normal Operation

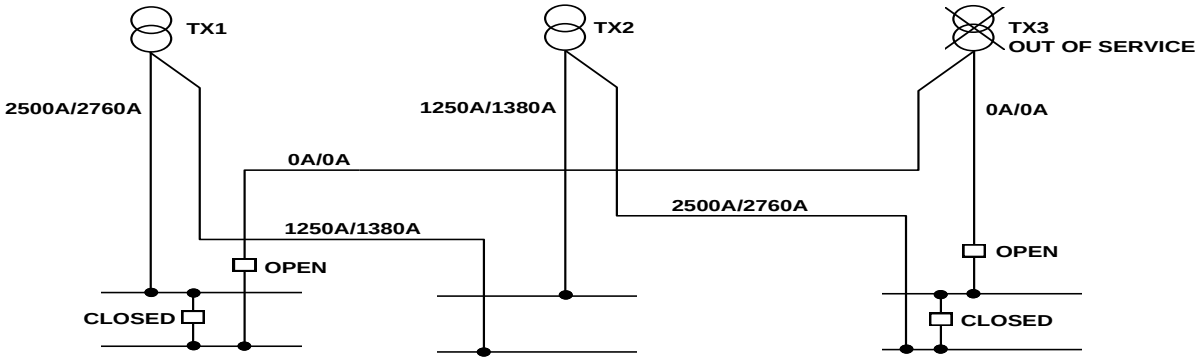
Summer/Winter LV Amps



Assuming the worst case scenario of TX3 failing and the maximum allowable firm rating of each transformer is based on two thirds of the emergency rating.

Emergency Operation

Summer/Winter LV Amps



Theoretically, the current in each of the transformer cables connected to TX1 and TX2 under these fault conditions can be calculated to be:

Cable 1.		1250A/1380A
	+	1250A/1380A
		2500A/2760A (Summer/Winter)
Cable 2.		1250A/1380A

Cable 1 is defined as the cable connected to the busbar previously supplied from the transformer out of service (TX3).

The maximum rating of the Group Busbar, Group CB's and Bus-Coupler (2000A) is lower than the above currents. The maximum rating of these elements is also lower than the cable rating. Hence the emergency rating of the zone substation is limited by the rating of the Group Busbar, Group CB's and Bus-Coupler which is 2000A.

Top Of This Section

THEODORE ZONE SUBSTATION

Contents - Zone Substation Information - **Theodore Zone Substation**
- Two Hour Emergency Rating
- Continuous Rating
- Normal & Emergency Operation (ZSS Diagram)

Z/S - THEODORE - TWO HOUR EMERGENCY RATING

Contents - Zone Substation Information - Theodore Zone Substation
- **Two Hour Emergency Rating**
- Continuous Rating
- Normal & Emergency Operation (ZSS Diagram)

EQUIPMENT "2 HOUR EMERGENCY" RATING			TX 1	TX 3
		(Summer/Winter)	**(1)/(2)**	**(1)/(2)**
TRANSFORMER		(MVA)	**62/69**	**62/69**
		(LV Amps)	**3255/3620**	**3255/3620**
		(HV Amps)	270/300 (Tyree)	270/300 (Tyree)
OLTC		(HV Amps)	400	400
HV Bushings		(HV Amps)	630	630
LV Bushings	(4)	(Amps per 2 bushings)	3200	3200
		(Summer/Winter)		
TX Cables		(LV Amps per Circuit)	1660/2000	1660/2000
(Copper PILC)	(Cable Size)		(630 mm^2)	(630 mm^2)
Group Busbar		(LV Amps)	2000	2000
		(Type)	(GEC.)	(GEC.)
Group Circuit Breakers and Bus-Coupler		(LV Amps)	2000 (GEC.)	2000 (GEC.)
ZONE EMERGENCY RATING (MVA)			**(3) 62/69 Summer/Winter**	

Notes:
(1) Summer limit
(2) Winter limit
(3) Rating of the substation is limited by the emergency rating of one transformer, i.e. 62/69 MVA total (summer/winter).
(4) This is a continuos rating. It has been assumed that the 2 hour bushing rating is 25% above the continuous rating
(5) If the maximum allowable firm rating of each transformer is based on half of the emergency rating them in the event of a failure of any one transformer the theoretical current in the transformer cables would be 1630/1810 Amps (summer/winter). Calculations are shown in Normal & Emergency Operation (ZSS Diagram). The emergency rating of the zone substation is therefore limited by the transformers.
(6) Note that the continuous rating for some equipment (OLTC, HV Bushings, LV Bushings, TX Cables, Group Busbar, Group CB's, and Bus-Coupler) is the same as the emergency rating.
(7) Ratings below 100 A are given to the nearest 1 A, and ratings above 100 A are given to the nearest 5 A.
(8) Transformer cable ratings require closer assessment and confirmation.

Top Of This Section

Z/S - THEODORE - CONTINUOUS RATING

Contents - Zone Substation Information - Theodore Zone Substation
- Two Hour Emergency Rating
- **Continuous Rating**
- Normal & Emergency Operation (ZSS Diagram)

EQUIPMENT CONTINUOUS RATING			TX 1	TX 3
TRANSFORMER		(MVA)	**(1) 45**	**(1) 45**
		(LV Amps)	**2360** (Tyree)	**2360** (Tyree)
OLTC		(HV Amps)	400	400
HV Bushings		(HV Amps)	630	630
LV Bushings	(4)	(Amps per 2 bushings)	3200	3200
TX Cables (Copper PILC)	(Cable Size)	(Summer/Winter) (LV Amps per Circuit)	1660/2000 (630 mm^2)	1660/2000 (630 mm^2)
Group Busbar		(LV Amps) (Type)	2000 (GEC.)	2000 (GEC.)
Group Circuit Breakers and Bus-Coupler		(LV Amps)	2000 (GEC.)	2000 (GEC.)
ZONE CONTINUOUS RATING (MVA)			**(2) 45/45 Summer/Winter**	

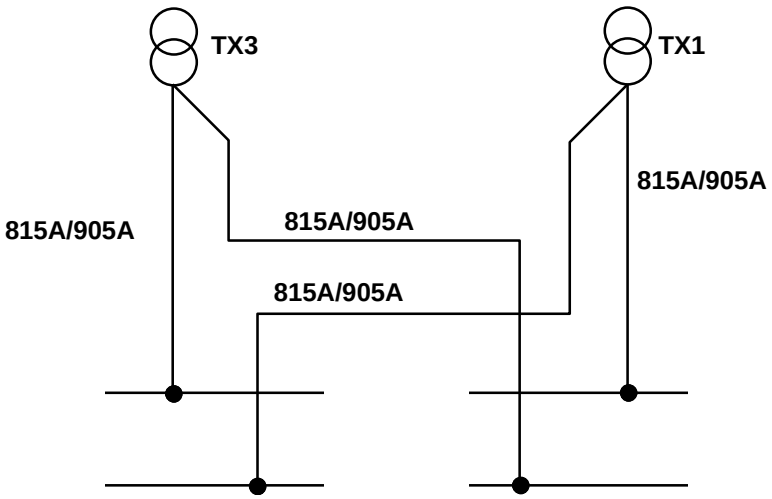
Notes:
(1) Summer and Winter limit
(2) Maximum continuous rating
(3) Note that the continuous rating for some equipment (OLTC, HV Bushings, LV Bushings, TX Cables, Group Busbar, Group CB's, and Bus-Coupler) is the same as the emergency rating.
(4) Ratings below 100 A are given to the nearest 1 A, and ratings above 100 A are given to the nearest 5 A.
(5) Transformer cable ratings require closer assessment and confirmation.

Top Of This Section

Contents - Zone Substation Information - Theodore Zone Substation
- Two Hour Emergency Rating
- Continuous Rating
- **Normal & Emergency Operation (ZSS Diagram)**

Normal Operation

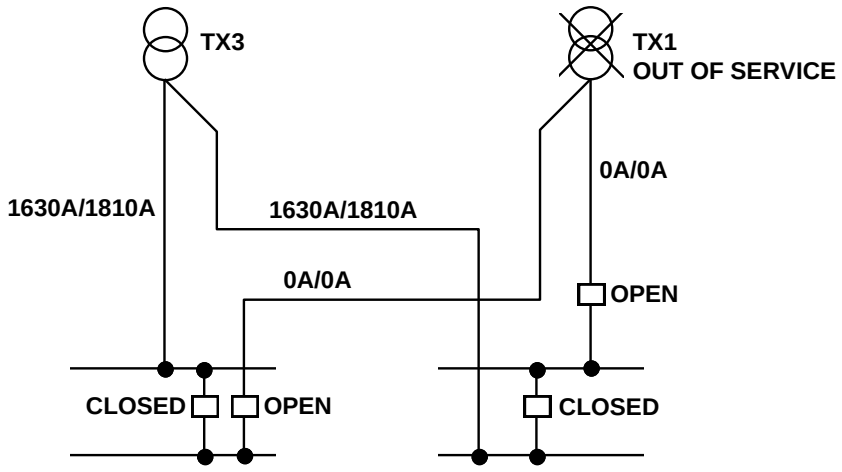
Summer/Winter LV Amps



Assuming the worst case scenario of TX1 failing and the maximum allowable firm rating of each transformer is based on half of the emergency rating.

Emergency Operation

Summer/Winter LV Amps



Theoretically, the current in each of the transformer cables connected to TX3 under these fault conditions can be calculated to be:

815A/ 905A
\+ 815A/ 905A
1630A/ 1810A

Since these limits are lower than the limits for the other components in the zone substation (cables, busbars, etc.), the emergency rating of the zone substation is limited by the rating of the transformers.

Top Of This Section

WANNIASSA ZONE SUBSTATION

Contents - Zone Substation Information - **Wanniassa Zone Substation**
- Two Hour Emergency Rating
- Continuous Rating
- Normal & Emergency Operation (ZSS Diagram)

Z/S - WANNIASSA - TWO HOUR EMERGENCY RATING

Contents - Zone Substation Information - Wanniassa Zone Substation
- **Two Hour Emergency Rating**
- Continuous Rating
- Normal & Emergency Operation (ZSS Diagram)

EQUIPMENT "2 HOUR EMERGENCY" RATING			TX 1	TX 2	TX 3
TRANSFORMER		(Summer/Winter) (MVA) (LV Amps) (HV Amps)	 74/82 3885/4305 325/360 (Tyree)	 70/78 3675/4095 305/340 (Tyree)	 70/78 3675/4095 305/340 (Tyree)
OLTC		(HV Amps)	500	400	400
HV Bushings		(HV Amps)	630	630	630
LV Bushings	(4)	(Amps per 2 bushings)	3200	3200	3200
TX Cables (Copper PILC)		**(Summer/Winter)** (LV Amps per Circuit) (Cable Size)	**(1)/(2)** **1660/2000** (Mixture of	**(1)/(2)** **1660/2000** 630 mm^2 & 1 in^2)	**(1)/(2)** **1660/2000** (630 mm^2)
Group Busbar		(LV Amps) (Type)	2000 (H.S.)	2000 (Email)	2000 (Email)
Group Circuit Breakers and Bus-Coupler		(LV Amps)	2000 (H.S.)	2000 (Email)	2000 (Email)
ZONE EMERGENCY RATING (MVA)				**95/114(3) Summer/Winter**	

Notes:
(1) Summer limit
(2) Winter limit
(3) Rating of the substation is limited by the rating of the transformer cables, i.e. 95/114 MVA total (summer/winter).
(4) This is a continuos rating. It has been assumed that the 2 hour bushing rating is 25% above the continuous rating
(5) If the firm rating of each transformer is based on two thirds of the total emergency rating then in the event of a failure of any one transformer the current in two transformer cable circuits would be 2590/2870 Amps (summer/winter). Calculations are shown in Normal & Emergency Operation (ZSS Diagram). As this is above the maximum rating of the cables the emergency rating of the zone substation is therefore limited by the rating of the transformer cables.
(6) Note that the continuous rating for some equipment (OLTC, HV Bushings, LV Bushings, TX Cables, Group Busbar, Group CB's, and Bus-Coupler) is the same as the emergency rating.
(7) The CT's for transformer differential protection (on 11kV Group CB's) are rated at 1925 Amps. The small difference between this and the winter rating of the transformer cables is considered to have no effect on the emergency rating.
(8) Ratings below 100 A are given to the nearest 1 A, and ratings above 100 A are given to the nearest 5 A.
(9) Transformer cable ratings require closer assessment and confirmation.

Top Of This Section

Z/S - WANNIASSA - CONTINUOUS RATING

Contents - Zone Substation Information - Wanniassa Zone Substation
- Two Hour Emergency Rating
- **Continuous Rating**
- Normal & Emergency Operation (ZSS Diagram)

EQUIPMENT CONTINUOUS RATING		TX 1	TX 2	TX 3
TRANSFORMER	(MVA) (LV Amps)	**(2)** **50** **2625** (Tyree)	**(2)** **50** **2625** (Tyree)	**(2)** **50** **2625** (Tyree)
OLTC	(HV Amps)	500	400	400
HV Bushings	(Amps per 2 bushings)	630	630	630
LV Bushings	(LV Amps)	3200	3200	3200
TX Cables (Copper PILC)	**(Summer/**Winter) (LV Amps per Circuit) (Cable Size)	**(1)** **1660**/2000 (Mixture of 630	**(1)** **1660**/2000 mm^2 & 1 in^2)	**(1)** **1660**/2000 (630 mm^2)
Group Busbar	(LV Amps) (Type)	2000 (H.S.)	2000 (Email)	2000 (Email)
Group Circuit Breakers and Bus-Coupler	(LV Amps)	2000 (H.S.)	2000 (Email)	2000 (Email)
ZONE CONTINUOUS RATING (MVA)			**(3)** **95/100** **Summer/Winter**	

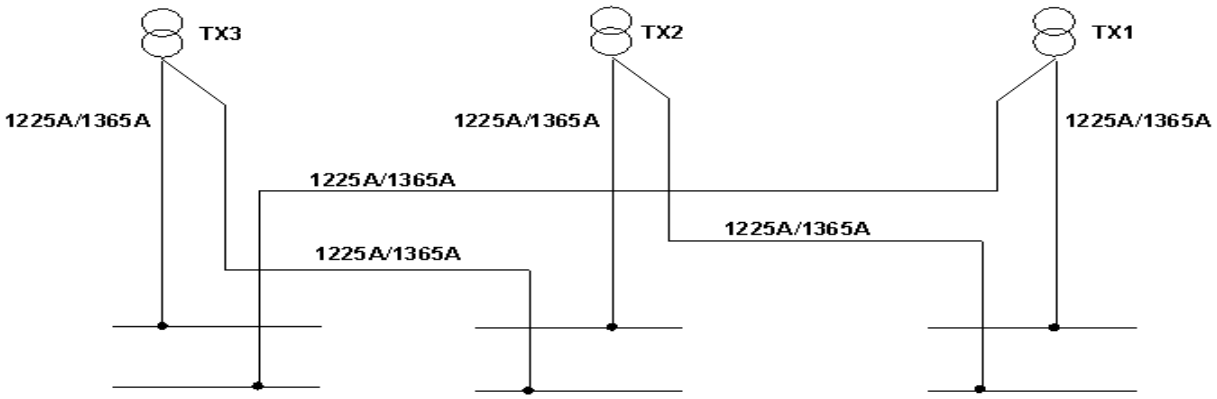
Notes:
(1) Summer limit
(2) Winter limit
(3) Maximum continuous rating
(4) Note that the continuous rating for some equipment (OLTC, HV Bushings, LV Bushings, TX Cables, Group Busbar, Group CB's, and Bus-Coupler) is the same as the emergency rating.
(5) The CT's for transformer differential protection (on 11kV Group CB's) are rated at 1925 Amps. The small difference between this and the winter rating of the transformer cables is considered to have no effect on the emergency rating.
(6) Ratings below 100 A are given to the nearest 1 A, and ratings above 100 A are given to the nearest 5 A.
(7) Transformer cable ratings require closer assessment and confirmation.

Top Of This Section

Contents - Zone Substation Information - Wanniassa Zone Substation
- Two Hour Emergency Rating
- Continuous Rating
- **Normal & Emergency Operation (ZSS Diagram)**

Normal Operation

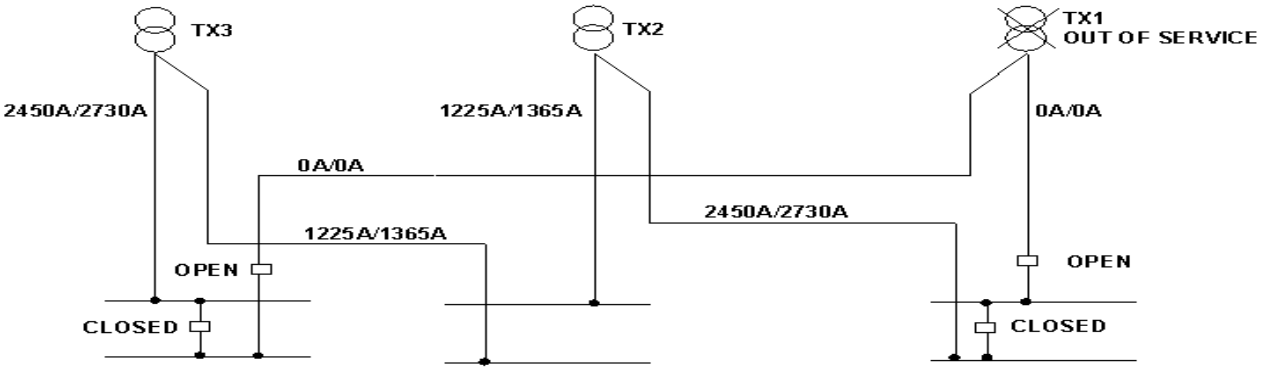
Summer/Winter LV Amps



Assuming the worst case scenario of TX1 failing and the maximum allowable firm rating of each transformer is based on two thirds of the emergency rating.

Emergency Operation

Summer/Winter LV Amps



Theoretically, the current in each of the transformer cables connected to TX2 and TX3 under these fault conditions can be calculated to be:

Cable 1. 1295A/1435A (Summer/Winter)

Cable 2. 1295A/1435A (Summer/Winter)
\+ 1295A/1435A
2590A/2870A (Summer/Winter)

Cable 1 is defined as the cable connected to the busbar previously supplied from the transformer out of service.
As the current in Cable 1 is above the maximum rating of the transformer cables (1660A/2000A), the emergency rating of the zone substation is therefore limited by the rating of the transformer cables.

Top Of This Section

WODEN ZONE SUBSTATION

Contents - Zone Substation Information - **Woden Zone Substation**
- Two Hour Emergency Rating
- Continuous Rating
- Normal & Emergency Operation (ZSS Diagram)

Z/S - WODEN - TWO HOUR EMERGENCY RATING

Contents - Zone Substation Information - Woden Zone Substation
- **Two Hour Emergency Rating**
- Continuous Rating
- Normal & Emergency Operation (ZSS Diagram)

EQUIPMENT "2 HOUR EMERGENCY" RATING			TX 1	TX 2	TX 3
TRANSFORMER		(Summer/Winter) (MVA) (LV Amps) (HV Amps)	74/82 3885/4305 325/360 (Tyree)	74/82 3885/4305 325/360 (Tyree)	73/81 3830/4250 320/355 (Tyree)
OLTC		(HV Amps)	500	500	500
HV Bushings		(HV Amps)	630	630	630
LV Bushings	(4)	(Amps per 2 bushings)	3200	3200	6000
TX Cables (Copper PILC)	(Cable Size)	**(Summer/Winter)** (LV Amps per Circuit)	**(1)/(2)** **1660/2000** (Mixture of	**(1)/(2)** **1660/2000** 630 mm^2 & 1 in^2)	**(1)/(2)** **1660/2000** (630 mm^2)
Group Busbar		(LV Amps) (Type)	2000 (Wes'House)	2000 (Wes'House)	2000 (H.S.)
Group Circuit Breakers and Bus-Coupler		(LV Amps)	2500 (GEC)	2500 (GEC)	2000 (H.S.)
ZONE EMERGENCY RATING (MVA)				**(3)** **95/114** **Summer/Winter**	

Notes:
(1) Summer limit
(2) Winter limit
(3) Rating of the substation is limited by the rating of the transformer cables and the group busbars, i.e. 95/114 MVA total (summer/winter).
(4) This is a continuos rating. It has been assumed that the 2 hour bushing rating is 25% above the continuous rating
(5) If the firm rating of each transformer is based on two thirds of the total emergency rating then in the event of a failure of any one transformer the current in two transformer cable circuits would be 2570/2850 Amps (summer/winter). Calculations are shown in Normal & Emergency Operation (ZSS Diagram). The emergency rating of the zone substation is therefore limited by the transformer cables.
(6) Note that the continuous rating for some equipment (OLTC, HV Bushings, LV Bushings, TX Cables, Group Busbar, Group CB's, and Bus-Coupler) is the same as the emergency rating.
(7) Ratings below 100 A are given to the nearest 1 A, and ratings above 100 A are given to the nearest 5 A.
(8) Transformer cable ratings require closer assessment and confirmation.

Top Of This Section

Z/S - WODEN - CONTINUOUS RATING

Contents - Zone Substation Information - Woden Zone Substation
- Two Hour Emergency Rating
- **Continuous Rating**
- Normal & Emergency Operation (ZSS Diagram)

EQUIPMENT CONTINUOUS RATING		TX 1	TX 2	TX 3
TRANSFORMER	(MVA) (LV Amps)	**(2)** **50** **2625** (Tyree)	**(2)** **50** **2625** (Tyree)	**(2)** **50** **2625** (Tyree)
OLTC	(HV Amps)	500	500	500
HV Bushings	(HV Amps)	630	630	630
LV Bushings	(Amps per 2 bushings)	3200	3200	6000
TX Cables (Copper PILC)	(**Summer**/Winter) (LV Amps per Circuit) (Cable Size)	**(1)** **1660**/2000 (Mixture of	**(1)** **1660/**2000 630 mm^2 & 1 in^2)	**(1)** **1660**/2000 (630 mm^2)
Group Busbar	(LV Amps) (Type)	1600 (Wes'House)	1600 (Wes'House)	2000 (H.S.)
Group Circuit Breakers and Bus-Coupler	(LV Amps)	2500 (GEC)	2500 (GEC)	2000 (H.S.)
ZONE CONTINUOUS RATING (MVA)			**(3)** **95/100** **Summer/Winter**	

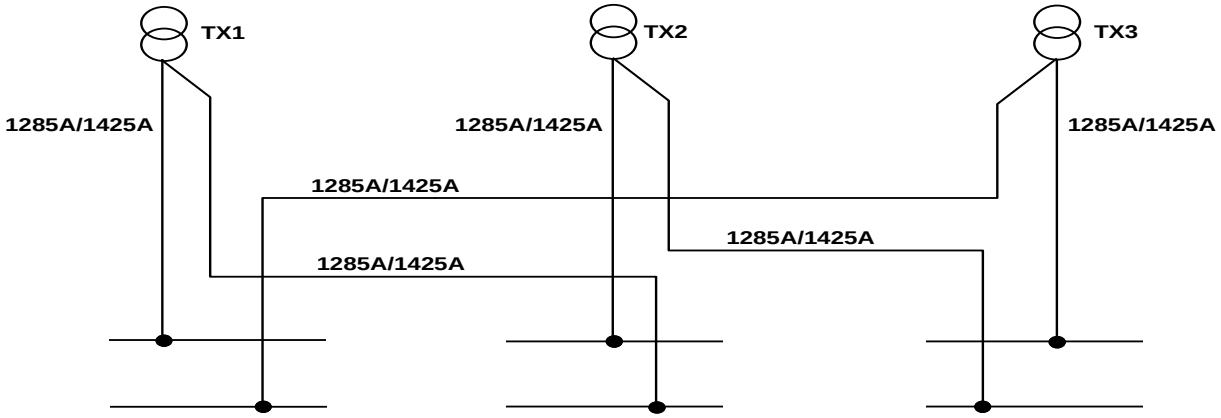
Notes:
(1) Summer limit
(2) Winter limit
(3) Maximum continuous rating
(4) Note that the continuous rating for some equipment (OLTC, HV Bushings, LV Bushings, TX Cables, Group Busbar, Group CB's, and Bus-Coupler) is the same as the emergency rating.
(5) Ratings below 100 A are given to the nearest 1 A, and ratings above 100 A are given to the nearest 5 A.
(6) Transformer cable ratings require closer assessment and confirmation.

Top Of This Section

Contents - Zone Substation Information - Woden Zone Substation
- Two Hour Emergency Rating
- Continuous Rating
- **Normal & Emergency Operation (ZSS Diagram)**

Normal Operation

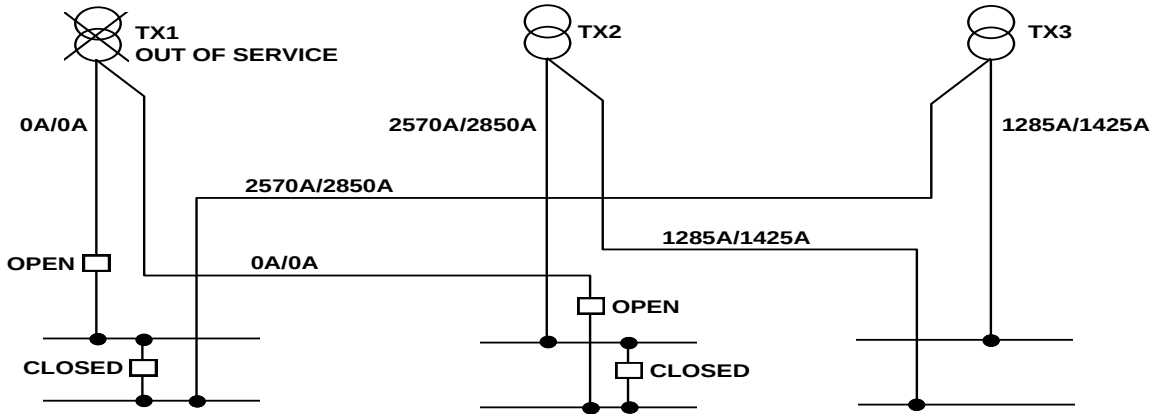
Summer/Winter LV Amps



Assuming the scenario of TX1 failing and the maximum allowable firm rating of each transformer is based on two thirds of the emergency rating.

Emergency Operation

Summer/Winter LV Amps



Theoretically, the current in each of the transformer cables connected to TX2 and TX3 under these fault conditions can be calculated to be:

Cable 1. 1285A/1425A
\+ 1285A/1425A
2570A/2850A (Summer/Winter)

Cable 2. 1285A/1425A (Summer/Winter)

Cable 1 is defined as the cable connected to the busbar previously supplied from the transformer out of service. As the current in Cable 1 is above the maximum rating of the transformer cables (1660A/2000A) the emergency rating of the zone substation is therefore limited by the rating of the transformer cables.

Top Of This Section

UNDERGROUND CABLES

TRANSMISSION UNDERGROUND CABLES **(132kV)**

High Voltage Cables (HV) (11kV)

Low Voltage Cables (LV) (0.6/1.0 kV)

Service Cables

Contents

TRANSMISSION UNDERGROUND CABLES

Transmission Cable Construction

Circuit Name	Manufacturer	Voltage (kV)	Insulation Type	Conductor	Metallic Screen	Length	Earthing
Causeway to Telopea Park	Iljin (South Korea)	132	XLPE	400 mm2 Copper	Copper screen wire with Aluminium laminated tape		Single point bonding

Transmission Cable Dimensions

	Causeway to Telopea Park		
Description	**Type**	**Nominal Thickness (mm)**	**Nominal Diameter (mm)**
Conductor	Copper (Circular compact stranded)		23.3
Conductor Binder	Semi-conductive tape		23.7
Conductor Screen	Semi-conductive compound	1.5	26.7
Insulation	Cross-linked polyethylene	21.0	68.7
Insulation Screen	Semi-conductive compound	1.2	71.1
Waterblocking Layer	Semi-conductive swellable tape	1.0	73.1
Metallic Screen	Annealed copper wire	#68 / 2.0	77.1
Waterblocking Layer	Semi-conductive swellable tape	1.0	79.1
Radial Water Barrier	Aluminium laminated tape	0.3	79.7
Outer Sheath	PVC/HDPE	2.0 / 2.0	83.7/87.7

Transmission Cable Electrical Characteristics

Description	Unit	Causeway to Telopea Park
Rated Voltage (Phase to Phase)	kV	132
Rated Voltage (Phase to Earth)	kV	76
Power Frequency withstand voltage for 1 minutes	kV	275
Power Frequency withstand voltage for 30 minutes	kV	190
Lightning Impulse withstand voltage	kV peak	650
Maximum d.c resistance @ 20°C	Ohms/km	0.0470
Maximum a.c resistance @ 90°C	Ohms/km	0.0614
Inductive reactance at 50Hz per phase	Ohms/km	0.2
Maximum electrostatic capacitance at 20°C per phase	µF/km	0.16
Positive sequence impedance at 50Hz @ 20°C and 90°C per phase	Ohms/km	0.204
Zero sequence impedance at 50Hz @ 20°C and 90°C per phase	Ohms/km	0.221
Short circuit conductor rating for 1 sec	kA	57.1
Short circuit screen rating for 1 sec	kA	32.8

HIGH VOLTAGE CABLES

Contents - Underground Cables - **High Voltage Cables**
- Cable Impedance
- Voltage Drop
- Ratings

Contents - Underground Cables - High Voltage Cables
- **Cable Impedance**
- Voltage Drop
- Ratings

CONDUCTOR			IMPEDANCE				CAPACITANCE
Type	Maximum Temperature (°C)	Nominal Area	R1 (ohm/km) @ 20°C	R1 (ohm/km) @40°C	R1 (ohm/km) @Max	X1 (ohm/km)	(μF/km)
Aluminium 11/ 11 kV Conductors (HV Belted Cables) (Note 1)	65	95 mm^2 185 mm^2 300 mm^2 400 mm^2	0.329 0.164 0.100 0.094	0.356 0.177 0.108 0.102	0.389 0.194 0.118 0.111	0.078 0.073 0.069 0.064	0.40 0.53 0.64 0.84
Aluminium 6.35/ 11 kV Conductor (HV Screened Cables) PILC (Note 2)	70	185 mm^2 300 mm^2 400 mm^2	0.165 0.102 0.079	0.178 0.110 0.085	0.198 0.122 0.095	0.074 0.071 0.069	0.84 1.05 1.17
Copper 11/ 11 kV Conductor Belted (Note 3)	65	0.1 in² 0.15 in² 0.2 in² 0.3 in² 0.4 in² 0.5 in²	0.276 0.188 0.142 0.092 0.068 0.056	0.297 0.202 0.152 0.099 0.074 0.060	0.323 0.220 0.166 0.108 0.080 0.065	0.089 0.084 0.081 0.078 0.075 0.074	0.35 0.41 0.46 0.54 0.61 0.66
Aluminium 6.35/ 11 kV XLPE, Screened (Note 4)	90	240 mm^2 300 mm^2 400 mm^2	0.126 0.101 0.080	0.137 0.110 0.086	0.162 0.130 0.102	0.096 0.093 0.090	0.43 0.47 0.53

Calculation notes:

(1) These cables are based on 3C, AL, PILC, belted, armoured cables.
- Impedance values have been obtained from existing tables @ 20°C (see below).

(2) These cables are based on 3C, AL, PILC, screened, armoured cables.
- R1 @70°C, X1 and Capacitance values are from "MM Cables Technical Data Manual. Al. Screened A4.1.4 - 37/89."
- Note that the X1 value obtained is a “Equivalent Star Reactance (Ω/km)”
- Other resistance values were obtained by using the Resistance Temperature Conversion formulae (see below).

(3) (3) These cables are based on 3C, Copper, PILC, belted, armoured.
- R1@20°C and X1 values were obtained from AEI General Information on cables and conductors, Section D, Electrical properties, Insulated twin and multicore cables, Table D4, p.145.
Conversion used: 1000 yards = 0.9144 km.
- Capacitance values are very approximate only and were calculated using "Equation (7), page 71, Power Cables, CC Barnes, Second Edition 1966, Chapman and Hall Ltd."
- d1 & d2 values obtained from "Table 19 [20?], Three core (Belted) 11000/11000 Volts, Paper Insulated Lead Sheathed Power Cables, Power Cables of Australia Pty. Limited."
- 8% increase to calculated value to take into account sector shaped conductors. (Applied only to capacitance values)

(4) The data above are based on 3C, AL, XLPE/HDPE, screened, unarmoured cables
- R1@90°C, X1, and Capacitance values were obtained from OLEX Cables – “Aluminium Conductors, High Fault Level, 6.35/11 kV Three Core, Individually Screened with Cu Wire, PVC Sheathed”, page 14 of “Power” Section.

(5) • Other resistance values were obtained by using the Resistance Temperature Conversion formula . See calculations section.

(6) Zero sequence values are not available.

Calculations: Resistance Temperature Conversion

Top Of This Section

Contents - Underground Cables - High Voltage Cables
- Cable Impedance
- **Voltage Drop**
- Ratings

CABLE TYPE	MAX TEMP. (°C)	CABLE NOMINAL AREA	VOLT/AMP.km (Phase to Neutral) Z1 @ 20°C (ohm/km)			VOLT/AMP.km (Phase to Neutral) Z1 @ 40°C (ohm/km)			VOLT/AMP.km (Phase to Neutral) Z1 @ Max Temp (ohm/km)		
			0.8pf	0.9pf	0.95pf	0.8pf	0.9pf	0.95pf	0.8pf	0.9pf	0.95pf
ALUMINIUM 11/11kV Belted (1)	65	95 mm^2	0.3100	0.3301	0.3369	0.3312	0.3540	0.3621	0.3577	0.3838	0.3936
		185 mm^2	0.1750	0.1794	0.1786	0.1856	0.1913	0.1912	0.1988	0.2062	0.2068
		300 mm^2	0.1214	0.1201	0.1165	0.1278	0.1273	0.1242	0.1359	0.1364	0.1338
		400 mm^2	0.1136	0.1125	0.1093	0.1197	0.1193	0.1165	0.1272	0.1278	0.1255
ALUMINIUM 6.35/11kV Screened (2)	70	185 mm^2	0.1762	0.1806	0.1797	0.1869	0.1925	0.1923	0.2028	0.2105	0.2112
		300 mm^2	0.1238	0.1223	0.1186	0.1304	0.1297	0.1264	0.1402	0.1407	0.1381
		400 mm^2	0.1047	0.1012	0.0967	0.1098	0.1070	0.1027	0.1174	0.1156	0.1118
COPPER 11/11kV Belted (3)	65	0.1 in^2	0.2741	0.2870	0.2897	0.2909	0.3059	0.3097	0.3119	0.3295	0.3346
		0.15 in^2	0.2006	0.2057	0.2048	0.2121	0.2186	0.2184	0.2264	0.2347	0.2354
		0.2 in^2	0.1620	0.1628	0.1599	0.1706	0.1725	0.1701	0.1814	0.1847	0.1829
		0.3 in^2	0.1201	0.1166	0.1116	0.1257	0.1229	0.1182	0.1328	0.1308	0.1266
		0.4 in^2	0.0999	0.0944	0.0885	0.1041	0.0991	0.0935	0.1093	0.1050	0.0997
		0.5 in^2	0.0891	0.0825	0.0761	0.0925	0.0863	0.0802	0.0968	0.0911	0.0852
ALUMINIUM 6.35/11kV XLPE, Screened (4)	90	240 mm^2	0.1585	0.1554	0.1499	0.1667	0.1646	0.1596	0.1870	0.1875	0.1838
		300 mm^2	0.1369	0.1318	0.1253	0.1434	0.1391	0.1331	0.1597	0.1575	0.1525

		400 mm^2	0.1176	0.1108	0.1037	0.1228	0.1166	0.1098	0.1356	0.1310	0.1250

Notes:
(1) The cables above are based on 3C, AL, PILC, belted, armoured.
(2) The cables above are based on 3C, AL, PILC, screened, armoured.
(3) The cables above are based on 3C, Cu, PILC, belted, armoured.
(4) The cables above are based on 3C, AL, XLPE/HDPE, screened, unarmoured.
(5) Voltage drop is based on phase to neutral voltage

Calculations: Voltage Drop Top Of This Section

Contents - Underground Cables - High Voltage Cables
- Cable Impedance
- Voltage Drop
- **Ratings**

CABLE TYPE	Conductor Size	No of Cables in Group	DIRECT IN GROUND						IN DUCT					
			Base Rating	Group Derating Factor	Domestic		Commercial		Base Rating	Group Derating Factor	Domestic		Commercial	
					Winter	Summer	Winter	Summer			Winter	Summer	Winter	Summer
			season derating factor		1.11	0.99	1.11	0.99	season derating factor		1.11	0.99	1.11	0.99
			cyclic derating factor		1.21	1.21	1.11	1.11	cyclic derating factor		1.21	1.21	1.11	1.11
3C AL 11/11kV Belted (1)	95 mm^2	1	170	1.00	230	205	210	185	140	1.00	190	170	170	155
		2		0.92	210	185	195	170		0.94	175	160	160	145
	185 mm^2	1	250	1.00	335	300	310	275	210	1.00	280	250	260	230
		2		0.92	310	275	285	255		0.94	265	235	245	215
		3		0.87	290	260	265	240		0.90	255	225	230	205
		4		0.84	280	250	260	230		0.87	245	220	225	200
		5		0.82	275	245	255	225		0.86	240	215	220	200
		6		0.81	270	245	250	225		0.85	240	215	220	195
		8		0.79	265	235	245	215		0.83	235	210	215	190
	300 mm^2	1	325	1.00	435	390	400	355	280	1.00	375	335	345	310
		2		0.92	400	360	370	330		0.94	355	315	325	290
		3		0.87	380	335	345	310		0.90	335	300	310	275
		4		0.84	365	325	335	300		0.87	325	290	300	270
		5		0.82	360	320	330	295		0.86	325	290	295	265
		6		0.81	355	315	325	290		0.85	320	285	295	260
		8		0.79	345	310	315	280		0.83	310	280	285	255
	400 mm^2	1	370	1.00	495	445	455	405	320	1.00	430	385	395	350
		2		0.92	455	410	420	375		0.94	405	360	370	330
		3		0.87	430	385	395	350		0.90	385	345	355	315
		4		0.84	415	370	380	340		0.87	375	335	345	305
		5		0.82	405	365	375	335		0.86	370	330	340	300
		6		0.81	405	360	370	330		0.85	365	325	335	300
		8		0.79	395	350	360	320		0.83	355	320	325	290

CABLE TYPE	Conductor Size	No of Cables in Group	DIRECT IN GROUND						IN DUCT					
			Base Rating	Group Derating Factor	Domestic		Commercial		Base Rating	Group Derating Factor	Domestic		Commercial	
					Winter	Summer	Winter	Summer			Winter	Summer	Winter	Summer
			season derating factor		1.11	0.99	1.11	0.99	season derating factor		1.11	0.99	1.11	0.99
			cyclic derating factor		1.21	1.21	1.11	1.11	cyclic derating factor		1.21	1.21	1.11	1.11
3C AL 6.36/11kV Screened (2)	185 mm^2	1	270	1.00	365	325	335	295	230	1.00	310	275	285	255
		2		0.92	335	300	305	275		0.94	290	260	265	240
		3		0.87	315	280	290	255		0.90	275	245	255	225
		4		0.84	305	270	280	250		0.87	270	240	245	220
		5		0.82	295	265	275	245		0.86	265	235	245	215
		6		0.81	295	260	270	240		0.85	260	235	240	215
		8		0.79	285	255	265	235		0.83	255	230	235	210
	300 mm^2	1	350	1.00	470	420	430	385	300	1.00	405	360	370	330
		2		0.92	430	385	395	355		0.94	380	340	345	310
		3		0.87	405	365	375	335		0.90	360	320	330	295
		4		0.84	395	350	360	320		0.87	350	315	320	285
		5		0.82	385	345	355	315		0.86	345	310	315	285
		6		0.81	380	340	350	310		0.85	340	305	315	280
		8		0.79	370	330	340	305		0.83	335	300	305	275
	400 mm^2	1	395	1.00	530	475	485	435	340	1.00	455	405	420	375
		2		0.92	490	435	450	400		0.94	430	385	395	350
		3		0.87	460	410	420	375		0.90	410	365	375	335
		4		0.84	445	395	405	365		0.87	395	355	365	325
		5		0.82	435	390	400	355		0.86	390	350	360	320
		6		0.81	430	385	395	350		0.85	385	345	355	315
		8		0.79	420	375	385	345		0.83	380	335	345	310
3C AL 6.35/11kV XLPE (4)	240 mm^2	1	370	1.00	495	445	455	405	320	1.00	430	385	395	350
		2		0.92	455	410	420	375		0.94	405	360	370	330
		3		0.87	430	385	395	350		0.90	385	345	355	315
		4		0.84	415	370	380	340		0.87	375	335	345	305
		5		0.82	405	365	375	335		0.86	370	330	340	300
		6		0.81	405	360	370	330		0.85	365	325	335	300
		8		0.79	395	350	360	320		0.83	355	320	325	290
	300 mm^2	1	420	1.00	565	505	515	460	365	1.00	490	435	450	400
		2		0.92	520	465	475	425		0.94	460	410	425	375

		3		0.87	490	435	450	400		0.90	440	390	405	360
		4		0.84	470	420	435	385		0.87	425	380	390	350
		5		0.82	465	415	425	380		0.86	420	375	385	345
		6		0.81	455	410	420	375		0.85	415	370	380	340
		8		0.79	445	395	410	365		0.83	405	360	375	330
	400 mm^2	1	480	1.00	645	575	590	525	415	1.00	555	495	510	455
		2		0.92	595	530	545	485		0.94	525	465	480	430
		3		0.87	560	500	515	455		0.90	500	445	460	410
		4		0.84	540	480	495	440		0.87	485	435	445	395
		5		0.82	530	470	485	435		0.86	480	425	440	390
		6		0.81	520	465	480	425		0.85	475	420	435	385
		8		0.79	510	455	465	415		0.83	460	410	425	380

CABLE TYPE	Conductor Size	No of Cables in Group	DIRECT IN GROUND						IN DUCT					
			Base Rating	Group Derating Factor	Domestic		Commercial		Base Rating	Group Derating Factor	Domestic		Commercial	
					Winter	Summer	Winter	Summer			Winter	Summer	Winter	Summer
			season derating factor		1.11	0.99	1.11	0.99	season derating factor		1.11	0.99	1.11	0.99
			cyclic derating factor		1.21	1.21	1.11	1.11	cyclic derating factor		1.21	1.21	1.11	1.11
3CCu11/11kVBelted(3)	70 mm^2	1	180	1.00	240	215	220	200	150	1.00	200	180	185	165
		2		0.92	220	200	205	180		0.94	190	170	175	155
	120 mm^2	1	250	1.00	335	300	310	275	215	1.00	290	260	265	235
		2		0.92	310	275	285	255		0.94	270	240	250	220
		3		0.87	290	260	265	240		0.90	260	230	240	210
		4		0.84	280	250	260	230		0.87	250	225	230	205
		5		0.82	275	245	255	225		0.86	250	220	225	205
		6		0.81	270	245	250	225		0.85	245	220	225	200
		8		0.79	265	235	245	215		0.83	240	215	220	195
	185 mm^2	1	315	1.00	425	375	390	345	265	1.00	355	315	325	290
		2		0.92	390	345	355	320		0.94	335	300	305	275
		3		0.87	365	325	335	300		0.90	320	285	295	260
		4		0.84	355	315	325	290		0.87	310	275	285	255
		5		0.82	345	310	320	285		0.86	305	270	280	250
		6		0.81	345	305	315	280		0.85	300	270	275	245
		8		0.79	335	300	305	275		0.83	295	265	270	240
	240 mm^2	1	365	1.00	490	435	450	400	315	1.00	425	375	390	345
		2		0.92	450	400	415	370		0.94	400	355	365	325
		3		0.87	425	380	390	350		0.90	380	340	350	310
		4		0.84	410	365	375	335		0.87	370	330	340	300
		5		0.82	400	360	370	330		0.86	365	325	335	295
		6		0.81	395	355	365	325		0.85	360	320	330	295
		8		0.79	385	345	355	315		0.83	350	315	320	285
	300 mm^2	1	410	1.00	550	490	505	450	350	1.00	470	420	430	385
		2		0.92	505	450	465	415		0.94	440	395	405	360
		3		0.87	475	425	440	390		0.90	420	375	385	345
		4		0.84	460	410	425	375		0.87	410	365	375	335
		5		0.82	450	405	415	370		0.86	405	360	370	330
		6		0.81	445	400	410	365		0.85	400	355	365	325
		8		0.79	435	390	400	355		0.83	390	345	355	320

CABLE TYPE	Conductor Size	No of Cables in Group	DIRECT IN GROUND						IN DUCT					
			Base Rating	Group Derating Factor	Domestic		Commercial		Base Rating	Group Derating Factor	Domestic		Commercial	
					Winter	Summer	Winter	Summer			Winter	Summer	Winter	Summer
			season derating factor		1.11	0.99	1.11	0.99	season derating factor		1.11	0.99	1.11	0.99
			cyclic derating factor		1.21	1.21	1.11	1.11	cyclic derating factor		1.21	1.21	1.11	1.11
3C Cu 11/11kV Belted (3)	0.1 in^2	1	185	1.00	250	220	230	205	145	1.00	195	175	180	160
		2		0.92	230	205	210	185		0.94	185	165	170	150
	0.2 in^2	1	260	1.00	350	310	320	285	215	1.00	290	260	265	235
		2		0.92	320	285	295	265		0.94	270	240	250	220
		3		0.87	305	270	280	250		0.90	260	230	240	210
		4		0.84	290	260	270	240		0.87	250	225	230	205
		5		0.82	285	255	265	235		0.86	250	220	225	205
		6		0.81	285	250	260	230		0.85	245	220	225	200
		8		0.79	275	245	255	225		0.83	240	215	220	195
	0.3 in^2	1	330	1.00	445	395	405	365	280	1.00	375	335	345	310
		2		0.92	410	365	375	335		0.94	355	315	325	290
		3		0.87	385	345	350	315		0.90	335	300	310	275
		4		0.84	370	330	340	305		0.87	325	290	300	270
		5		0.82	365	325	335	295		0.86	325	290	295	265
		6		0.81	360	320	330	295		0.85	320	285	295	260
		8		0.79	350	310	320	285		0.83	310	280	285	255
	0.4 in^2	1	390	1.00	525	465	480	430	325	1.00	435	390	400	355
		2		0.92	480	430	440	395		0.94	410	365	375	335
		3		0.87	455	405	415	370		0.90	390	350	360	320
		4		0.84	440	390	400	360		0.87	380	340	350	310
		5		0.82	430	385	395	350		0.86	375	335	345	305
		6		0.81	425	380	390	345		0.85	370	330	340	305
		8		0.79	415	370	380	340		0.83	360	320	330	295
	0.5 in^2	1	430	1.00	580	515	530	475	360	1.00	485	430	445	395
		2		0.92	530	475	485	435		0.94	455	405	415	370
		3		0.87	500	445	460	410		0.90	435	385	400	355
		4		0.84	485	430	445	395		0.87	420	375	385	345
		5		0.82	475	420	435	385		0.86	415	370	380	340
		6		0.81	470	415	430	385		0.85	410	365	375	335
		8		0.79	455	405	420	375		0.83	400	355	365	330

CABLE TYPE	Conductor Size	No of Cables in Group	DIRECT IN GROUND						IN DUCT					
			Base Rating	Group Derating Factor	Domestic		Commercial		Base Rating	Group Derating Factor	Domestic		Commercial	
					Winter	Summer	Winter	Summer			Winter	Summer	Winter	Summer
			season derating factor		1.11	0.99	1.11	0.99	season derating factor		1.11	0.99	1.11	0.99
			cyclic derating factor		1.21	1.21	1.11	1.11	cyclic derating factor		1.21	1.21	1.11	1.11
3C Cu 6.35/11kV XLPE (4)	185 mm^2	1	410	1.00	550	490	505	450	350	1.00	470	420	430	385
		2		0.92	505	450	465	415		0.94	440	395	405	360
		3		0.87	475	425	440	390		0.90	420	375	385	345
		4		0.84	460	410	425	375		0.87	410	365	375	335
		5		0.82	450	405	415	370		0.86	405	360	370	330
		6		0.81	445	400	410	365		0.85	400	355	365	325
		8		0.79	435	390	400	355		0.83	390	345	355	320
	240 mm^2	1	475	1.00	640	570	585	520	410	1.00	550	490	505	450
		2		0.92	585	525	540	480		0.94	520	460	475	425
		3		0.87	555	495	505	450		0.90	495	440	455	405
		4		0.84	535	475	490	435		0.87	480	425	440	390
		5		0.82	525	465	480	430		0.86	475	420	435	385
		6		0.81	515	460	475	425		0.85	465	415	430	380
		8		0.79	505	450	460	410		0.83	455	405	420	375
	300 mm^2	1	530	1.00	710	635	655	580	460	1.00	620	550	565	505
		2		0.92	655	585	600	535		0.94	580	520	535	475
		3		0.87	615	550	565	505		0.90	555	495	510	455
		4		0.84	595	530	545	485		0.87	540	480	495	440
		5		0.82	585	520	535	480		0.86	530	475	485	435
		6		0.81	575	515	530	470		0.85	525	465	480	430
		8		0.79	560	500	515	460		0.83	510	455	470	420
	400 mm^2	1	600	1.00	805	720	740	660	520	1.00	700	625	640	570
		2		0.92	740	660	680	605		0.94	655	585	600	535
		3		0.87	700	625	640	570		0.90	625	560	575	510
		4		0.84	675	600	620	550		0.87	610	540	555	495
		5		0.82	660	590	605	540		0.86	600	535	550	490
		6		0.81	655	580	600	535		0.85	590	530	545	485

		8		0.79	635	570	585	520		0.83	580	515	530	475

Notes:

(1) These cables are based on 3C, AL, PILC, belted, armoured – Maximum Temperature: 65°C

(2) These cables are based on 3C, AL, PILC, screened, armoured – Maximum Temperature: 70°C
The ratings of screened cables are based on the corresponding belted cable rating +5%, rounded to the nearest multiple of 5. This allows for the higher maximum conductor temperature of screened cables. This is an approximate rating only.

(3) These cables are based on 3C, Cu, PILC, belted, armoured – Maximum Temperature: 65°C

(4) These cables are based on 3C, AL, XLPE/HDPE, screened, unarmoured.

The relevant factors used are:

Effect	Factor
Approximate Cable Separation (centre to centre) Group Derating Factor – 2 in Group – Directly Buried Group Derating Factor – 4 in Group – Directly Buried Group Derating Factor – 6 in Group – Directly Buried Group Derating Factor – 2 in Group – In Duct Group Derating Factor – 4 in Group – In Duct Group Derating Factor – 6 in Group – In Duct	0.45 m 0.90 0.80 0.76 0.93 0.84 0.81
ACT Winter Ground Temperature Winter Temperature Factor ACT Summer Ground Temperature Summer Temperature Factor	10°C 1.11 27°C 0.99
Domestic cyclic rating factor Commercial cyclic rating factor	1.21 1.11
Soil thermal resistivity Derating due to soil thermal resistivity Conductor Burial Depth Derating due to depth	1.20°C.m/W 1.00 0.80 m 1.00

Notes on Al 6.35/11kV XLPE Rating Factors:

- Commercial Load Cycle: 8 hours on and 16 hours off.
- Domestic Load Cycle (Canberra): calculated using winter daily load characteristics of a feeder supplying domestic load in the ACT.
- Ref: "THERMAL CYCLIC RATINGS OF 111kV CABLES" File Ref: G89/568.
- Due to installation method cable ratings for City East 400 XLPE feeder cables have to be reduced by 5%.
- Grouped derating factors were obtained from “MM Cables Product Specification and Technical Data.” – Section 2 – “Design Selection and Installation”.

Top Of This Section

LOW VOLTAGE CABLES

Contents - Underground Cables - **Low Voltage Cables**
- Cable Impedance
- Voltage Drop
- Cable Ratings

Contents - Underground Cables - Low Voltage Cables
- **Cable Impedance**
- Voltage Drop
- Cable Ratings

CABLE		POSITIVE SEQUENCE IMPEDANCE				ZERO SEQUENCE IMPEDANCE	
Type ALUMINIUM	Nominal Area (mm^2)	R1 (ohm/km) @ 20°C	R1 (ohm/km) @ 40°C	R1 (ohm/km) @ 90°C	X1 (ohm/km)	R0 (ohm/km) @ 20°C	X0 (ohm/km) @ 20°C
3 Core Screened (1)	185 240 300	0.165 0.126 0.101	0.178 0.137 0.110	0.211 0.162 0.130	0.063 0.062 0.061	** ** **	** ** **
4 Core XLPE Insulated	120 185 240	0.253 0.165 0.126	0.274 0.178 0.137	0.325 0.211 0.162	0.062 0.063 0.062	1.01 0.66 0.50	0.062 0.062 0.062

Notes:
(1) For the 3 Core, neutral screen, insulated cables
(2) R1 @90°C and X1 values are from "MM Cables Technical Data Manual." – "Al. XLPE Insulated; Screened A4.1.2 - 35A/89."
(3) Note that the X1 value obtained is a "Equivalent Star Reactance (Ω/km)"
(4) For the 4 Core XLPE:
(5) R1 @90°C, X1, R0, and X0 values were obtained from AS 4026-1992, Appendix A, Table A5 – 0.6/1 kV XLPE INSULATED DISTRIBUTOR CABLES
(6) Other resistance values were obtained from the resistance values (from above), and using the resistance temperature conversion formula, see below.
(7) XLPE insulated cables have a maximum conductor operating temperature of 90°C.
(8) Capacitance values for the cables are not available.
(9) ** = Value not available.

Calculations: Resistance Temperature Conversion

Top Of This Section

Contents - Underground Cables - Low Voltage Cables
- Cable Impedance
- **Voltage Drop**
- Cable Ratings

CABLE TYPE ALUMINIUM	NOMINAL AREA (mm^2)	VOLT/AMP.km Phase to Neutral Z1 @ 20°C (ohm/km)			VOLT/AMP.km Phase to Neutral Z1 @ 40°C (ohm/km)			VOLT/AMP.km Phase to Neutral Z1 @ 90°C (ohm/km)		
		0.8pf	0.9pf	0.95pf	0.8pf	0.9pf	0.95pf	0.8pf	0.9pf	0.95pf
3 Core Screened	185	0.1695	0.1756	0.1760	0.1801	0.1875	0.1886	0.2066	0.2174	0.2201
	240	0.1383	0.1407	0.1394	0.1464	0.1499	0.1491	0.1668	0.1728	0.1733
	300	0.1177	0.1178	0.1154	0.1243	0.1252	0.1231	0.1406	0.1436	0.1425
4 Core XLPE Insulated	120	0.2400	0.2552	0.2602	0.2563	0.2736	0.2796	0.2972	0.3195	0.3281
	185	0.1695	0.1756	0.1760	0.1801	0.1875	0.1886	0.2066	0.2174	0.2201
	240	0.1383	0.1407	0.1394	0.1464	0.1499	0.1491	0.1668	0.1728	0.1733

Notes:
(1) Voltage drop is based on phase to neutral voltage

Calculations: Voltage Drop

Top Of This Section

Contents - Underground Cables - Low Voltage Cables
- Cable Impedance
- Voltage Drop
- **Cable Ratings**

CABLE TYPE	NOMINAL CABLE AREA (mm^2)	NUMBER OF CABLES IN TRENCH	DIRECT IN GROUND			IN DUCT		
			Domestic Winter (Amps)	Commercial Winter (Amps)	Commercial Summer (Amps)	Domestic Winter (Amps)	Commercial Winter (Amps)	Commercial Summer (Amps)
3 Core Screened (1)	185	1	420	385	345	355	325	290
		2	340	310	280	320	295	260
		3	295	270	240	300	275	245
		4	265	240	215	275	250	225
	240	1	490	450	400	415	380	340
		2	395	365	325	370	340	305
		3	345	315	280	345	320	285
		4	310	285	255	320	290	260
	300	1	560	515	460	470	430	385
		2	455	415	370	425	390	345
		3	395	360	320	395	365	325
		4	355	325	290	360	330	295
4 Core XLPE Insulated (2)	120	1	335	310	275	285	260	230
		2	270	250	220	255	235	210
		3	235	215	190	240	220	195
		4	210	195	175	220	200	180
	185	1	430	390	350	360	330	295
		2	345	320	285	325	300	265
		3	300	275	245	305	280	250
		4	270	245	220	280	255	230
	240	1	500	460	410	420	385	345
		2	405	370	330	380	350	310
		3	350	320	285	355	325	290
		4	315	290	260	325	295	265

Notes
(1) These values are based on the current rating values obtained from "MM Cables Technical Data Manual." – "Al. XLPE Insulated; Screened A4.1.2 - 35A/89." Derating factors are shown below.
(2) These values are based on the maximum continuous current rating values in AS 4026-1992, Appendix A, Table A5 – 0.6/1 kV XLPE INSULATED DISTRIBUTOR CABLES, for "direct buried" and "in duct" cables. Derating factors are shown below.
(3) These values are rounded to the nearest 5 Amps.

(4) The current ratings were multiplied by the following factors according to the varying conditions:

Effect	Factor
Approximate Cable Separation (centre to centre)	Touching
Group Derating Factor – 2 in Group – Directly Buried	0.81
Group Derating Factor – 3 in Group – Directly Buried	0.70
Group Derating Factor – 4 in Group – Directly Buried	0.63
Group Derating Factor – 2 in Group – In Duct	0.90
Group Derating Factor – 3 in Group – In Duct	0.84
Group Derating Factor – 4 in Group – In Duct	0.77
ACT Winter Ground Temperature	10°C
Winter Temperature Factor	1.11
ACT Summer Ground Temperature	27°C
Summer Temperature Factor	0.99
Domestic cyclic rating factor	1.21
Commercial cyclic rating factor	1.11
Soil thermal resistivity	1.20°C.m/W
Derating due to soil thermal resistivity	1.00
Depth	0.80 m
Derating due to depth (3 Core Screened)	0.96
Derating due to depth (4 Core XLPE) ^^	0.979592

(5) Notes on rating factors:

- Commercial Load Cycle: 8 hours on and 16 hours off.
- Domestic Load Cycle (Canberra): calculated using winter daily load characteristics of a feeder supplying essentially domestic load in the ACT.
- Grouped derating factors were obtained from “MM Cables Product Specification and Technical Data.” – Section 2 – “Design Selection and Installation”.
- The values for the 4 Core XLPE were obtained from AS 4026. These values were quoted at a depth of 0.6m. To obtain values at 0.5m, the values were divided by 0.98, and then to get values at 0.8m, the values were multiplied by 0.96.

Top Of This Section

SERVICE CABLES

Contents - Underground Cables - **Service Cables**
- Cable Impedance
- Voltage Drop
- Cable Ratings
- Minimum Bending Radius

Contents - Underground Cables - Service Cables
- **Cable Impedance**
- Voltage Drop
- Cable Ratings
- Minimum Bending Radius

CABLE TYPE COPPER mm^2	CONDUCTOR IMPEDANCE				ZERO SEQUENCE IMPEDANCE	
	R1 (ohm/km)			X1 (ohm/km)	R0 (ohm/km)	X0 (ohm/km)
	@ 20°C	@40°C	@ 90°C		@ 20°C	@ 20°C
16 mm^2, 1 Core (1)	1.16	1.25	1.47	0.152	**	**
16 mm^2, 3 Core (1)	1.16	1.25	1.47	0.130	**	**
50 mm^2, 3 Core (1)	0.390	0.420	0.494	0.107	**	**
16 mm^2, 4 Core (2)	1.16	1.25	1.47	0.089	4.6	0.089
25 mm^2, 4 Core (2)	0.677	0.729	0.858	0.086	2.91	0.086
35 mm^2, 4 Core (2)	0.527	0.568	0.668	0.084	2.10	0.084

Notes:
(1) These cables are based on Copper XLPE insulated, neutral screened. R1 @ 90°C and X1 values were obtained from MM Cable Technical Data Manual C4.1.2 pages 11 and 41. The cables listed in this reference were not of the same rating as those listed above; hence the values of X1 are approximate only.
(2) These cables are Copper 4 Core, XLPE insulated service cables.
(3) R1 @ 90°C and X1 values were obtained from AS 4026 – 1992; page 18; table A6.
(4) R1 @ 20°C and 40°C are calculated using the adjustment formula contained in the calculations section.
(5) ** = Not Available

Calculations: Resistance Temperature Conversion

Top Of This Section

Contents - Underground Cables - Service Cables
- Cable Impedance
- **Voltage Drop**
- Cable Ratings
- Minimum Bending Radius

CABLE TYPE	VOLT/AMP.km								
COPPER 0.6/1kV (XLPE, Screened) (mm^2)	Z1 @ 20°C			Z1 @ 40°C			Z1 @ 90°C		
	0.8pf	0.9pf	0.95pf	0.8pf	0.9pf	0.95pf	0.8pf	0.9pf	0.95pf
16 mm^2 1C (1)	1.0196	1.1107	1.1499	1.0903	1.1903	1.2339	1.2672	1.3893	1.4440
16 mm^2 3C (1)	1.0064	1.1011	1.1431	1.0771	1.1807	1.2271	1.2540	1.3797	1.4371
50 mm^2 3C (1)	0.3762	0.3976	0.4039	0.4000	0.4244	0.4321	0.4594	0.4912	0.5027
16 mm^2 4C (2)	0.9818	1.0832	1.1303	1.0525	1.1628	1.2143	1.2294	1.3618	1.4243
25 mm^2 4C (2)	0.5935	0.6471	0.6703	0.6348	0.6936	0.7194	0.7380	0.8097	0.8420
35 mm^2 4C (2)	0.4723	0.5112	0.5272	0.5044	0.5474	0.5654	0.5848	0.6378	0.6608

Notes:

(1) These cables are Cu, XLPE Insulated, Screened cables. Reactance values have not been available and have been estimated. XLPE cables have a maximum conductor temperature of 90°C.
(1) These are 4 core, Copper XLPE insulated service cables. XLPE cables have a maximum temperature of 90°C.
(2) Volt drop values in the table are phase to neutral. The voltage drop on the neutral conductor is not included.

Calculations: Voltage Drop

Top Of This Section

U/G - SERVICE - CABLE RATINGS

Contents - Underground Cables - Service Cables
- Cable Impedance
- Voltage Drop
- **Cable Ratings**
- Minimum Bending Radius

CABLE TYPE	NOMINAL CABLE AREA	DIRECT IN GROUND	IN DUCT
COPPER	16 mm^2 1C	125	115
0.6/1kV	16 mm^2 3C	110	92
(3 C,XLPE, Screened) (1)	50 mm^2 3C	200	165
COPPER	16 mm^2 4C	105	86
0.6/1kV	25 mm^2 4C	140	120
(4 core, XLPE) (2)	35 mm^2 4C	160	130

Notes:

1) These values were obtained from MM Cable Technical Data Manual. The cables listed in the MM reference are not the same as those listed above; hence these values need to be confirmed.These ratings are based on:
   - Soil ambient temperature of 25°C
   - Soil thermal resistivity of 1.2°C m/W
   - Burial depth of 600 mm
2) These values were obtained from AS 4026 – 1992; page 18; table A6. These ratings are based on (see page 15 of AS 4026):
   - Soil ambient temperature of 25°C
   - Soil thermal resistivity of 1.2°C m/W
   - Burial depth of 600 mm for direct in ground, and for in duct cables, the duct is 125 mm UPVC Class 6 to AS 1477

Top Of This Section

U/G - SERVICE - MINIMUM BENDING RADIUS

Contents - Underground Cables - Service Cables
- Cable Impedance
- Voltage Drop
- Cable Ratings
- **Minimum Bending Radius**

	RECOMMENDED MINIMUM BENDING RADIUS		MINIMUM DIAMETER OF DRUM BARREL
COPPER 0.6/1kV (XLPE)	During Installation (Times Cable Diameter)	Setting (Times Cable Diameter)	(Times Cable Diameter)
16 mm^2 4C	6	4	5
25 mm^2 4C	6	4	5
35 mm^2 4C	9	6	8

Notes:
(1) These values were obtained from AS 4026 – 1992; page 18; table A6.

Top Of This Section

OVERHEAD CONDUCTORS

O/H - APPROXIMATE METRIC EQUIVALENTS OF IMPERIAL CONDUCTORS

Contents - Overhead Conductors - **Approximate Metric Equivalents of Imperial Conductors**

Imperial Conductor			Approximate Metric Equivalent		
Code Word	Stranding	Type	Code Word	Stranding	Type
COPPER					
N/A	7/.080	HD	N/A	7/2.00	HD
N/A	7/.104	HD	N/A	7/2.75	HD
N/A	19/.064	HD	N/A	7/2.75	HD
N/A	19/.083	HD	N/A	7/3.50	HD
N/A	19/.101	HD	N/A	19/2.75	HD
N/A	37/.083	HD	N/A	19/3.00	HD
ALUMINIUM					
WASP	7/.173	AAC	MERCURY	7/4.50	AAC
HORNET	19/.128	AAC	NEPTUNE	19/3.25	AAC
BLUEBELL	37/.168	AAC	URANUS	61/3.25	AAC
SCORPION	37/.168	AAC	URANUS	61/3.25	AAC
STEEL CORED ALUMINIUM					
FERRET	6/1/.118	ACSR	APPLE	6/1/3.00	ACSR/GZ
MINK	6/1/.144	ACSR	BANANA	6/1/3.75	ACSR/GZ
WOLF	30/7/.102	ACSR	GRAPE	30/7/2.50	ACSR/GZ
PANTHER	30/7/.118	ACSR	LEMON	30/7/3.00	ACSR/GZ
MOOSE	54/7/.139	ACSR	OLIVE	54/7/3.50	ACSR/GZ
STEEL					
3/12	3/.104	GS	NA	3/2.75	SC/GZ

Notes:

(1) This table only shows imperial conductors with their metric equivalent. Some metric conductors are not shown, as they are not the equivalent of an imperial conductor.

Top Of This Section

O/H - COPPER EQUIVALENCE

Contents - Overhead Conductors - **Copper Equivalence**

Code word	Measurement System	Stranding	Type	Equivalent Copper area (mm^2) (1)
COPPER				
N/A	Metric	7/2.00	HD	22
N/A	Imperial	7/.080	HD	23
N/A	Imperial	7/.104	HD	38
N/A	Imperial	19/.064	HD	39
N/A	Metric	7/2.75	HD	42
N/A	Imperial	19/.083	HD	66
N/A	Metric	7/3.50	HD	67
N/A	Imperial	19/.101	HD	98
N/A	Metric	19/2.75	HD	113
N/A	Imperial	37/.083	HD	129
N/A	Metric	19/3.00	HD	134
ALUMINIUM				
WASP	Imperial	7/.173	AAC	66
MERCURY	Metric	7/4.50	AAC	69
HORNET	Imperial	19/.128	AAC	97
NEPTUNE	Metric	19/3.25	AAC	97
URANUS	Metric	61/3.25	AAC	311
BLUEBELL	Imperial	37/.168	AAC	326
SCORPION	Imperial	37/.168	AAC	326
STEEL CORED ALUMINIUM				
RAISIN	Metric	3/4/2.50	ACSR/GZ	11
FERRET	Imperial	6/1/.118	ACSR	26
APPLE	Metric	6/1/3.00	ACSR/GZ	26
MINK	Imperial	6/1/.144	ACSR	39
BANANA	Metric	6/1/3.75	ACSR/GZ	41
GRAPE	Metric	30/7/2.50	ACSR/GZ	90
WOLF	Imperial	30/7/.102	ACSR	97
PANTHER	Imperial	30/7/.118	ACSR	130
LEMON	Metric	30/7/3.00	ACSR/GZ	130
OLIVE	Metric	54/7/3.50	ACSR/GZ	319
MOOSE	Imperial	54/7/.139	ACSR	325
STEEL				
3/12	Imperial	3/.104	GS	1.7

Notes:

1. Sorted in ascending order, within conductor material type. Values were rounded to nearest 1 mm^2. Conductor Types:
   - **HD** Hard Drawn
   - **AAC** All Aluminium Conductor
   - **ACSR/GZ** Aluminium Conductor Galvanised Steel Reinforced
   - **ACSR** Aluminium Conductor Steel Reinforced
   - **GS** Galvanised Steel
2. Scorpion is only used for Subtransmission (not used for Distribution or Service Conductors). Therefore, it is only listed in the Subtransmission table; and the ratings table. It is not included in any other table.

Calculations: Overhead – Copper Equivalence
Top Of This Section

O/H - SUBTRANSMISSION LINES
CURRENT CARRYING CAPACITY

Contents - Overhead Conductors - Subtransmission

- **Current Carrying Capacity**

LINE		CURRENT RATING (AMPS)			
		SUMMER DAY		WINTER DAY	
FROM	TO	CONTINUOUS	EMERGENCY	CONTINUOUS	EMERGENCY
Canberra	Woden	1950	2960	2540	3320
Canberra	Latham	1950	2958	2540	3320
Canberra	Gold Creek	1930	2920	2520	3280
Latham	Belconnen	1950	2960	2540	3320
Bruce	Belconnen	1930	2920	2520	3280
Bruce	Gold Creek	1930	2920	2520	3280
Bruce	Civic	1930	2930	2520	3290
Bruce	City East	970	1460	1260	1640
Bruce	Causeway	970	1460	1260	1640
Woden	Wanniassa	1990	3000	2590	3370
Civic	Woden	1950	2960	2540	3330
Causeway	City East	970	1460	1260	1640
Gilmore	Causeway	1930	2920	2510	3280
Wanniassa	Gilmore	1930	2960	2510	3280
Gilmore	Williamsdale	970	1460	1260	1640
Gilmore	Theodore	970	1460	1260	1640
Theodore	Williamsdale	970	1460	1220	1640
Causeway	Telopea Park	NA(1)	NA(1)	NA(1)	NA(1)
Fyshwick	Queanbeyan	500	840	820	1040

Notes:

1. Bundle Conductor for Williamsdale line is limited by the single conductor.
2. A proper calculations of the rating of the 132 kV cables from Causeway to Telopea Park have not been conducted due to a lack of data on the soil and sand-cement mix thermal resistivity. However, it has been estimated that the cable should be capable of carrying at least 90 MVA (390 A) in summer and winter per 3 phase circuit.
3. Overhead conductor ratings have been calculated for the following conditions:

Condition	Ambient Temperature (Ta) (°C)	Solar Radiation Intensity (W/m^2)
Summer Day	35	1000
Winter Day	15	850

   - Emissivity of conductor, e: 0.5
   - Solar absorption coefficient, a: 0.5
   - Wind speed = 1.0 m/s.
   - These conditions are the same as the conditions used to calculate the high voltage current rating values.
   - Continuous Ratings are for a conductor temperature of 75°C.
   - Emergency Ratings are for a conductor temperature of 120°C.
4. Values are rounded to nearest 10 A.
5. Current ratings are per line. Where a line has various conductors in it, then the line's rating is the minimum of the ratings of the conductors.

Calculations: Overhead – Current Ratings

Top Of This Section

OPTICAL GROUND WIRE (OPGW)

OPGW Description:

Location	Manufacturer Name	Cable Type	Cable Diameter (mm)	CSA of AS wire (mm2)	CSA of AA wire (mm2)	Fibre Type	Number of fibre	R_{DC} @ 20°C (Ω / km)	Short circuit current for 0.5 sec (kA)
Gilmore-Williamsdale & Theodore - Williamsdale	ZhongTian (China)	OPGW-24B1-201	18.7	68.42	133.32	G.652D (SM)	24	0.177	26.8

HV DISTRIBUTION CONDUCTORS

Contents - Overhead Conductors - HV Distribution Conductors
- **Conductor Impedance**
- Voltage Drop
- Conductor Ratings

CONDUCTOR	POSITIVE SEQUENCE IMPEDANCE				ZERO SEQUENCE IMPEDANCE			
	R1 (ohm/km)			X1 (ohm/km)	R0 (ohm/km)			X0
	20°C	40°C	75°C	GMD=1.28m (2)	20°C	40°C	75°C	(ohm/km)
COPPER								
7/2.00	0.827	0.890	1.000	0.401	0.977	1.040	1.150	1.733
7/.080	0.801	0.862	0.969	0.400	0.951	1.012	1.119	1.732
7/.104	0.477	0.513	0.577	0.383	0.627	0.663	0.727	1.716
19/.064	0.464	0.500	0.562	0.379	0.614	0.650	0.712	1.712
7/2.75	0.440	0.474	0.532	0.381	0.590	0.624	0.682	1.713
19/.083	0.276	0.297	0.334	0.363	0.426	0.447	0.484	1.695
7/3.50	0.272	0.292	0.329	0.366	0.422	0.442	0.479	1.698
19/.101	0.186	0.201	0.226	0.350	0.336	0.351	0.376	1.683
19/2.75	0.162	0.175	0.196	0.346	0.312	0.325	0.346	1.679
37/.083	0.142	0.153	0.172	0.341	0.292	0.303	0.322	1.673
19/3.00	0.136	0.147	0.165	0.340	0.286	0.297	0.315	1.673
ALUMINIUM								
WASP	0.274	0.296	0.335	0.351	0.424	0.446	0.485	1.684
MERCURY	0.261	0.282	0.319	0.350	0.411	0.432	0.469	1.682
HORNET	0.185	0.200	0.226	0.335	0.335	0.350	0.376	1.668
NEPTUNE	0.185	0.200	0.227	0.335	0.335	0.350	0.377	1.668
URANUS	0.058	0.063	0.071	0.297	0.208	0.213	0.221	1.630
BLUEBELL	0.055	0.060	0.068	0.296	0.205	0.210	0.218	1.629
ACSR								
RAISIN	1.701	1.838	2.078	0.387	1.851	1.988	2.228	1.719
FERRET	0.737	0.796	0.900	0.375	0.887	0.946	1.050	1.708
APPLE	0.756	0.817	0.924	0.375	0.906	0.967	1.074	1.708
MINK	0.509	0.550	0.622	0.363	0.659	0.700	0.772	1.695
BANANA	0.484	0.523	0.591	0.361	0.634	0.673	0.741	1.694
GRAPE	0.199	0.215	0.244	0.330	0.349	0.365	0.394	1.662
WOLF	0.186	0.201	0.227	0.328	0.336	0.351	0.377	1.660
PANTHER	0.139	0.150	0.170	0.318	0.289	0.300	0.320	1.651
LEMON	0.138	0.150	0.169	0.318	0.288	0.300	0.319	1.651
OLIVE	0.060	0.065	0.073	0.293	0.210	0.215	0.223	1.625
MOOSE	0.059	0.064	0.072	0.292	0.209	0.214	0.222	1.625
STEEL								
3/12	10.560	11.489	13.115	0.6725 (1)	10.710	11.639	13.265	1.741

Notes:
1. Result obtained from measurements conducted by the ESAA, 1959.
2. Geometric Mean Distance (GMD) of 1.28m (delta type 1 construction; conductor separation 1.6m. A-B, 1.14m. B-C, 1.14m. A-C).

Calculations:
Overhead – DC Resistance
Overhead – AC Resistance
Overhead – Positive Sequence Reactance
Overhead – HV – Zero Sequence Impedance
Overhead – HV – Zero Sequence Reactance

Top Of This Section

Contents - Overhead Conductors - HV Distribution Conductors
- Conductor Impedance
- **Voltage Drop**
- Conductor Ratings

CONDUCTOR	VOLT/AMP.km (Phase to Neutral) Z1 @ 20°C			VOLT/AMP.km (Phase to Neutral) Z1 @ 40°C			VOLT/AMP.km (Phase to Neutral) Z1 @ 75°C		
	0.8 pf	0.9 pf	0.95 pf	0.8 pf	0.9 pf	0.95 pf	0.8 pf	0.9 pf	0.95 pf
COPPER									
7/2.00	0.9018	0.9187	0.9105	0.9522	0.9754	0.9704	1.0404	1.0747	1.0751
7/.080	0.8806	0.8951	0.8857	0.9294	0.9500	0.9437	1.0148	1.0461	1.0451
7/.104	0.6114	0.5962	0.5727	0.6405	0.6289	0.6072	0.6914	0.6862	0.6676
19/.064	0.5988	0.5831	0.5594	0.6271	0.6149	0.5930	0.6767	0.6706	0.6519
7/2.75	0.5804	0.5620	0.5369	0.6073	0.5921	0.5687	0.6542	0.6450	0.6245
19/.083	0.4384	0.4065	0.3755	0.4553	0.4255	0.3955	0.4847	0.4586	0.4305
7/3.50	0.4367	0.4038	0.3722	0.4532	0.4225	0.3919	0.4822	0.4551	0.4263
19/.101	0.3593	0.3205	0.2865	0.3707	0.3333	0.3000	0.3906	0.3556	0.3236
19/2.75	0.3373	0.2968	0.2621	0.3472	0.3079	0.2739	0.3645	0.3274	0.2944
37/.083	0.3181	0.2764	0.2414	0.3268	0.2862	0.2517	0.3420	0.3033	0.2697
19/3.00	0.3133	0.2711	0.2358	0.3216	0.2804	0.2457	0.3362	0.2968	0.2630
ALUMINIUM									
WASP	0.4300	0.3998	0.3701	0.4477	0.4197	0.3910	0.4786	0.4545	0.4278
MERCURY	0.4189	0.3877	0.3575	0.4358	0.4066	0.3775	0.4653	0.4398	0.4125
HORNET	0.3495	0.3130	0.2808	0.3615	0.3265	0.2950	0.3824	0.3500	0.3198
NEPTUNE	0.3496	0.3131	0.2809	0.3616	0.3266	0.2951	0.3825	0.3501	0.3200
URANUS	0.2248	0.1818	0.1480	0.2285	0.1860	0.1524	0.2351	0.1934	0.1602
BLUEBELL	0.2221	0.1790	0.1451	0.2256	0.1830	0.1494	0.2319	0.1900	0.1568
ACSR									
RAISIN	1.5925	1.6991	1.7363	1.7022	1.8225	1.8665	1.8941	2.0384	2.0944
FERRET	0.8149	0.8270	0.8174	0.8624	0.8804	0.8739	0.9456	0.9740	0.9726
APPLE	0.8302	0.8443	0.8357	0.8790	0.8991	0.8936	0.9643	0.9951	0.9950
MINK	0.6247	0.6161	0.5967	0.6575	0.6530	0.6356	0.7150	0.7176	0.7038
BANANA	0.6040	0.5931	0.5726	0.6352	0.6282	0.6097	0.6898	0.6897	0.6746
GRAPE	0.3575	0.3233	0.2925	0.3703	0.3377	0.3077	0.3928	0.3631	0.3345
WOLF	0.3451	0.3099	0.2787	0.3571	0.3234	0.2929	0.3781	0.3470	0.3178
PANTHER	0.3021	0.2637	0.2313	0.3110	0.2738	0.2419	0.3267	0.2914	0.2605
LEMON	0.3018	0.2634	0.2310	0.3108	0.2735	0.2416	0.3264	0.2911	0.2602
OLIVE	0.2235	0.1815	0.1483	0.2274	0.1858	0.1529	0.2342	0.1935	0.1609
MOOSE	0.2224	0.1803	0.1472	0.2262	0.1846	0.1517	0.2328	0.1921	0.1596
STEEL									
3/12	8.8513	9.7969	10.242	9.5947	10.633	11.125	10.896	12.097	12.669

Notes:
1. Geometric Mean Distance (GMD) = 1.28m (delta type 1 construction; conductor separation 1.6m. A-B, 1.14m. B-C, 1.14m. A-C).
2. Voltage drop values are phase to neutral.

Calculations: Voltage Drop
Top Of This Section

OH – HV and LV - CONDUCTORs CURRENT CAPACITY

Contents - Overhead Conductors - HV Distribution Conductors
- Conductor Impedance
- Voltage Drop
- **Conductor Ratings**

CONDUCTOR				SUMMER DAY (amps)			WINTER DAY (amps)			WINTER NIGHT (amps)		
MATERIAL	**TYPE**	**TEMP (°C)**	**WIND SPEED (m/s)**	0.0	0.5	1.0 rating	0.0	0.5	1.0 rating	0.0	0.5	1.0 rating
COPPER	**7/2.00**	**75**		92	154	182	128	195	229	150	213	247
		50		NA	81	102	86	149	177	118	174	202
	7/.080	**75**		94	157	186	131	199	233	153	218	252
		50		NA	82	104	88	151	180	120	178	206
	7/.104	**75**		129	215	256	183	274	322	216	302	350
		50		NA	108	139	121	208	247	170	247	285
	19/.064	**75**		132	219	260	187	280	328	221	309	357
		50		NA	110	142	124	212	252	174	252	291
	7/2.75	**75**		136	226	268	193	288	339	228	318	368
		50		NA	113	146	128	218	260	180	260	300
	19/.083	**75**		182	301	358	261	386	453	313	429	495
		50		NA	143	189	170	290	346	246	350	404
	7/3.50	**75**		183	303	360	263	389	456	315	432	499
		50		NA	144	190	171	292	349	248	353	407
	19/.101	**75**		232	382	455	336	492	578	407	552	635
		50		NA	172	234	216	367	439	321	449	518
	19/2.75	**75**		253	415	495	369	537	630	449	603	694
		50		NA	184	251	235	399	478	352	491	566
	37/.083	**75**		274	450	537	405	583	684	494	657	755
		50		NA	194	270	254	433	518	387	535	616
	19/3.00	**75**		281	461	550	416	598	702	508	674	774
		50		NA	198	275	261	444	531	398	549	632
ALUMINIUM	**WASP**	**75**		192	315	375	278	407	477	338	456	525
		50		NA	141	192	179	304	363	266	372	429
	MERCURY 7/4.5 AAC	**75**		197	324	386	287	419	492	350	470	541
		50		NA	144	197	184	313	374	275	384	442
	HORNET	**75**		245	400	478	366	520	610	448	588	675
		50		NA	167	236	229	385	462	351	480	552
	NEPTUNE 19/3.25 AAC	**75**		245	400	478	366	520	610	448	588	675
		50		NA	167	236	229	385	462	351	480	552
	URANUS 61/3.25 AAC	**120 (For 132kV)**		1021	1262	1458	1189	1424	1638	1322	1540	1749
		75		534	806	968	818	1072	1257	1021	1244	1419
		50		NA	224	409	495	772	932	802	1015	1158
	BLUEBELL	**75**		550	829	995	845	1103	1293	1055	1281	1461
		50		NA	224	417	510	794	959	828	1045	1193
	SCORPION 37/4.27 AAC	**120 (For 132kV)**		1054	1299	1501	1228	1466	1687	1365	1587	1802
		75		550	829	995	845	1103	1293	1055	1281	1461
		50		NA	224	417	510	794	959	828	1045	1193

CONDUCTOR				SUMMER DAY (amps)			WINTER DAY (amps)			WINTER NIGHT (amps)		
MATERIAL	**TYPE**	**TEMP (°C)**	**WIND SPEED**	0.0 m/s	0.5 m/s	1.0 m/s	0.0 m/s	0.5 m/s	1.0 m/s	0.0 m/s	0.5 m/s	1.0 m/s
STEEL CORED ALUMINIUM	**RAISIN**	**75**		67	112	133	95	143	167	112	157	182
		50		NA	57	73	63	108	129	88	128	149
	FERRET	**75**		107	177	210	152	226	266	181	250	289
		50		NA	87	113	100	171	204	142	205	237
	APPLE	**75**		105	175	208	150	223	262	178	247	286
		50		NA	86	112	99	169	201	141	202	234
	MINK	**75**		135	222	265	194	286	335	233	318	367
		50		NA	105	139	126	215	256	183	260	300
	BANANA	**75**		139	229	273	200	295	346	240	328	379
		50		NA	107	143	130	221	264	190	268	310
	GRAPE	**75**		242	392	468	363	511	599	445	579	664
		50		NA	159	228	226	377	452	349	472	543
	WOLF	**75**		254	409	489	381	534	626	468	606	695
		50		NA	63	236	237	394	472	367	495	568
	PANTHER	**120 (For 132kV)**		578	747	865	673	840	970	744	903	1030
		75		309	488	583	466	640	750	575	731	837
		50		NA	181	273	288	469	563	452	596	683
	LEMON	**120 (For 132kV)**		579	748	866	674	841	971	745	904	1031
		75		309	488	584	467	640	751	576	731	838
		50		NA	181	273	288	469	564	452	597	684
	OLIVE	**120 (For 132kV)**		1035	1267	1463	1206	1430	1644	1341	1550	1758
		75		538	805	967	828	1074	1259	1036	1251	1425
		50		NA	201	397	499	770	931	814	1020	1164
	MOOSE	**120 (For 132kV)**		1048	1281	1479	1220	1446	1663	1358	1568	1778
		75		545	813	977	838	1086	1273	1049	1265	1441
		50		NA	200	400	504	778	941	824	1032	1177
STEEL	**3/12**	**75**		25	42	50	35	53	62	41	58	67
		50		NA	22	28	24	41	48	32	48	55

Notes:

1. Shaded values are recommended ratings for the distribution 11 kV lines. Note that these ratings are for a conductor temperature of 75°C, and a wind speed of 1.0 m/s.
2. Conductor specifications are in accordance with Metal Manufactures Ltd. Publication 5/81-October 1981, "Kembla®, Conductors for Overhead Transmission and Distribution."
3. Conductor temperatures of 120°C are used in the 132 kV system (marked with "In 132kV System").
4. Conditions for which the ratings have been calculated are as follows:

Condition	Ambient Temperature (Ta) (°C)	Solar Radiation Intensity (W/m^2)
Summer Day	35	1000
Winter Day	15	850
Winter Night	10	0

   - Emissivity of conductor, e: 0.5
   - Solar absorption coefficient, a: 0.5
5. Values are rounded to nearest 1A.
6. NA = Not Available

Calculations: Overhead – Current Ratings

Top Of This Section

Contents - Overhead Conductors - LV Distribution Conductors
- **Conductor Impedance**
- Voltage Drop
- Conductor Ratings

CONDUCTOR	POSITIVE SEQUENCE IMPEDANCE				ZERO SEQUENCE IMPEDANCE					
	R1 (ohm/km)			X1 (ohm/km)	Z0 @ 20°C (ohm/km)		Z0 @ 40°C (ohm/km)		Z0 @ 75°C (ohm/km)	
	@ 20°C	@ 40°C	@ 75°C	GMD=0.96m	R0	X0	R0	X0	R0	X0
COPPER										
7/2.00	0.827	0.890	1.000	0.383	1.303	1.290	1.370	1.319	1.482	1.364
7/.080	0.801	0.862	0.969	0.382	1.275	1.276	1.341	1.305	1.451	1.351
7/.104	0.477	0.513	0.577	0.365	0.881	1.078	0.932	1.100	1.018	1.137
19/.064	0.464	0.500	0.562	0.361	0.865	1.065	0.916	1.086	1.000	1.122
7/2.75	0.440	0.474	0.532	0.363	0.828	1.053	0.877	1.073	0.960	1.107
19/.083	0.276	0.297	0.334	0.345	0.569	0.933	0.607	0.943	0.670	0.963
7/3.50	0.272	0.292	0.329	0.347	0.560	0.936	0.597	0.946	0.659	0.965
19/.101	0.186	0.201	0.226	0.332	0.407	0.870	0.434	0.875	0.482	0.886
19/2.75	0.162	0.175	0.196	0.328	0.360	0.853	0.385	0.857	0.428	0.865
37/.083	0.142	0.153	0.172	0.323	0.322	0.836	0.344	0.839	0.382	0.845
19/3.00	0.136	0.147	0.165	0.322	0.310	0.834	0.331	0.837	0.368	0.843
ALUMINIUM										
WASP	0.274	0.296	0.335	0.333	0.572	0.911	0.611	0.923	0.678	0.944
MERCURY	0.261	0.282	0.319	0.332	0.549	0.902	0.587	0.913	0.652	0.933
HORNET	0.185	0.200	0.226	0.317	0.410	0.840	0.440	0.846	0.491	0.858
NEPTUNE	0.185	0.200	0.227	0.317	0.411	0.840	0.440	0.846	0.491	0.858
URANUS	0.058	0.063	0.071	0.279	0.144	0.723	0.154	0.723	0.172	0.724
BLUEBELL	0.055	0.060	0.068	0.278	0.150	0.725	0.160	0.726	0.179	0.727
ACSR										
RAISIN	1.701	1.838	2.078	0.369	1.217	1.217	1.283	1.248	1.392	1.297
FERRET	0.737	0.796	0.900	0.357	0.938	1.069	0.994	1.094	1.087	1.137
APPLE	0.756	0.817	0.924	0.357	0.414	0.825	0.444	0.831	0.495	0.843
MINK	0.509	0.550	0.622	0.345	0.321	0.789	0.345	0.792	0.385	0.800
BANANA	0.484	0.523	0.591	0.343	0.152	0.713	0.163	0.714	0.182	0.715
GRAPE	0.199	0.215	0.244	0.312	1.238	1.227	1.305	1.258	1.416	1.307
WOLF	0.186	0.201	0.227	0.310	0.904	1.051	0.959	1.075	1.049	1.117
PANTHER	0.139	0.150	0.170	0.300	0.441	0.835	0.472	0.842	0.526	0.856
LEMON	0.138	0.150	0.169	0.300	0.321	0.789	0.344	0.792	0.384	0.799
OLIVE	0.060	0.065	0.073	0.275	0.155	0.715	0.166	0.715	0.185	0.717
MOOSE	0.059	0.064	0.072	0.274	2.141	1.535	2.266	1.556	2.487	1.586
STEEL										
3/12	10.560	11.489	13.115	0.6725 (1)	10.773	1.759	11.698	1.760	13.317	1.763

Notes:
(1) Result for steel conductor obtained from measurements conducted by the ESAA, 1959.
(2) (Geometric Mean Distance (GMD) of 0.96m: flat construction; conductor separation 0.5m. A-B, 1.1m. B-C, 1.6m. A-C, An 1.1m; Bn 0.6m; Cn 0.5m).
(3) Construction is 3 phase and 1 neutral conductor.
(4) Zero sequence values have been calculated with a ground wire i.e. neutral 415V.

Calculations:
Overhead – DC Resistance
Overhead – AC Resistance

Overhead – Positive Sequence Reactance
Overhead – LV – Zero Sequence Impedance

Top Of This Section

Contents - Overhead Conductors - LV Distribution Conductors
- Conductor Impedance
- **Voltage Drop**
- Conductor Ratings

CONDUCTOR	VOLT/AMP.km (Phase to Neutral) Z1 @ 20°C (ohm/km)			VOLT/AMP.km (Phase to Neutral) Z1 @ 40°C (ohm/km)			VOLT/AMP.km (Phase to Neutral) Z1 @ 75°C (ohm/km)		
	0.8pf	0.9pf	0.95pf	0.8pf	0.9pf	0.95pf	0.8pf	0.9pf	0.95pf
COPPER									
7/2.00	0.8910	0.9109	0.9049	0.9414	0.9676	0.9647	1.0296	1.0668	1.0695
7/.080	0.8697	0.8872	0.8800	0.9185	0.9421	0.9380	1.0040	1.0382	1.0395
7/.104	0.6006	0.5884	0.5671	0.6297	0.6211	0.6016	0.6805	0.6783	0.6620
19/.064	0.5880	0.5752	0.5538	0.6163	0.6070	0.5874	0.6658	0.6628	0.6462
7/2.75	0.5696	0.5541	0.5313	0.5964	0.5843	0.5631	0.6434	0.6371	0.6188
19/.083	0.4276	0.3986	0.3698	0.4444	0.4176	0.3898	0.4739	0.4507	0.4248
7/3.50	0.4258	0.3959	0.3666	0.4424	0.4146	0.3862	0.4713	0.4472	0.4206
19/.101	0.3485	0.3126	0.2808	0.3598	0.3254	0.2943	0.3797	0.3478	0.3180
19/2.75	0.3265	0.2889	0.2565	0.3364	0.3000	0.2682	0.3537	0.3195	0.2888
37/.083	0.3073	0.2686	0.2358	0.3159	0.2783	0.2461	0.3311	0.2954	0.2641
19/3.00	0.3025	0.2632	0.2302	0.3108	0.2726	0.2400	0.3253	0.2889	0.2573
ALUMINIUM									
WASP	0.4192	0.3919	0.3644	0.4369	0.4118	0.3854	0.4678	0.4466	0.4221
MERCURY	0.4081	0.3798	0.3518	0.4249	0.3987	0.3719	0.4544	0.4319	0.4069
HORNET	0.3387	0.3051	0.2752	0.3506	0.3186	0.2894	0.3715	0.3421	0.3142
NEPTUNE	0.3388	0.3053	0.2753	0.3507	0.3187	0.2895	0.3717	0.3423	0.3144
URANUS	0.2140	0.1739	0.1423	0.2177	0.1781	0.1468	0.2242	0.1855	0.1545
BLUEBELL	0.2112	0.1711	0.1395	0.2148	0.1751	0.1437	0.2210	0.1822	0.1511
ACSR									
RAISIN	1.5817	1.6912	1.7307	1.6913	1.8146	1.8609	1.8832	2.0305	2.0888
FERRET	0.8040	0.8191	0.8118	0.8515	0.8726	0.8682	0.9347	0.9661	0.9670
APPLE	0.8194	0.8364	0.8300	0.8681	0.8913	0.8880	0.9535	0.9873	0.9893
MINK	0.6139	0.6082	0.5910	0.6467	0.6451	0.6300	0.7041	0.7097	0.6982

BANANA	0.5931	0.5852	0.5670	0.6243	0.6203	0.6041	0.6790	0.6818	0.6689
GRAPE	0.3466	0.3154	0.2868	0.3595	0.3299	0.3021	0.3820	0.3552	0.3288
WOLF	0.3343	0.3021	0.2731	0.3463	0.3155	0.2873	0.3672	0.3391	0.3122
PANTHER	0.2912	0.2558	0.2256	0.3002	0.2659	0.2362	0.3158	0.2835	0.2548
LEMON	0.2910	0.2556	0.2253	0.2999	0.2656	0.2360	0.3156	0.2832	0.2545
OLIVE	0.2127	0.1736	0.1427	0.2165	0.1780	0.1473	0.2233	0.1856	0.1553
MOOSE	0.2115	0.1724	0.1415	0.2153	0.1767	0.1460	0.2220	0.1842	0.1539
STEEL 3/12	8.8513	9.7969	10.242	9.595	10.633	11.125	10.896	12.097	12.669

Notes:
1. Geometric Mean Distance (GMD) = 0.96m (flat construction; conductor separation 0.5m. A-B, 1.1m. B-C, 1.6m. A-C).
2. Voltage Drops are phase to neutral. Voltage drop values do not include voltage drop in the neutral conductor.

Calculations: Voltage Drop

Top Of This Section

LV AERIAL BUNDLED CONDUCTORS

Contents - Overhead Conductors - **LV Aerial Bundled Conductors**

Properties of 4 core aerial bundled conductors:

Nominal Cross Sectional Area (mm^2)	95	150
Maximum AC resistance @80°C (R1) (Ω/km)	0.398	0.257
Positive Sequence Reactance @50Hz (X1) (Ω/km)	0.0853	0.0821
Maximum continuous temperature (°C)	80	80
Current Rating per phase (Amps)	225	285

Notes:
1. Refer to: AS 3560 – 1991, Table E2, page 20.

SERVICE CONDUCTORS

Contents - Overhead Conductors - Service Conductors
- **Conductor Impedance**
- Voltage Drop
- Conductor Ratings

COPPER CONDUCTOR	POSITIVE SEQUENCE IMPEDANCE				ZERO SEQUENCE IMPEDANCE			
	R1 (ohm/km)			X1 (ohm/km)	R0 (ohm/km)			X0 (ohm/km)
	@ 20°C	@ 40°C	@ 75°C		@ 20°C	@ 40°C	@ 75°C	
Imperial (inches)								
7/.044 4WL HD	2.6356	2.8364	3.1879	0.3836	10.542	11.346	12.7511	0.1049
7/.044 2CTW HD	2.6356	2.8364	3.1879	NEG	N/A	N/A	N/A	N/A
7/.044 4CTW HD	2.6356	2.8364	3.1879	NEG	10.542	11.346	12.7511	NEG
7/.064 4WL HD	1.2456	1.3405	1.5066	0.3601	4.9824	5.3621	6.0265	0.0971
7/.064 2CTW HD	1.2456	1.3405	1.5066	NEG	N/A	N/A	N/A	N/A
7/.064 4CTW HD	1.2456	1.3405	1.5066	NEG	4.9824	5.3621	6.0265	NEG
37/.083 4WL	0.1327	0.1428	0.1605	0.2869	0.5306	0.5711	0.6418	0.0726
Metric (mm)								
7/1.35 4WL	1.8788	2.0220	2.2725	0.3717	7.5152	8.0880	9.0900	0.1009
7/1.35 2CTW	1.8788	2.0220	2.2725	0.0900	N/A	N/A	N/A	N/A
7/1.35 4CTW	1.8788	2.0220	2.2725	0.0400	7.5152	8.0880	9.0900	0.0300
7/1.70 4WL	1.1400	1.2269	1.3789	0.3572	4.5600	4.9075	5.5155	0.0961
7/1.70 2CTW	1.1400	1.2269	1.3789	0.0800	N/A	N/A	N/A	N/A
7/1.70 4CTW	1.1400	1.2269	1.3789	0.0300	4.5600	4.9075	5.5155	0.0300
19/1.35 4WL	0.6664	0.7172	0.8060	0.3369	2.6656	2.8687	3.2242	0.0893
19/1.53 4WL	0.5192	0.5588	0.6280	0.3291	2.0768	2.2351	2.5120	0.0867
19/2.14 4WL	0.2654	0.2856	0.3210	0.3080	1.0616	1.1425	1.2841	0.0797

Notes:
1. NEG = Negligible
2. NA = Not Available
3. HD = Hard Drawn
4. 4WL = 4 wire lateral service (3 phase + neutral), spaced 300mm apart.
5. 2CTW = 2 core twisted service (1 phase + neutral).
6. 4CTW = 4 core twisted service (3 phase + neutral).

Calculations
Overhead – DC Resistance
Overhead – AC Resistance
Overhead – Positive Sequence Reactance
Resistance Temperature Conversion

Top Of This Section

Contents - Overhead Conductors - Service Conductors
- Conductor Impedance
- **Voltage Drop**
- Conductor Ratings

COPPER CONDUCTOR	VOLT/AMP.km (Phase to Neutral) Z1 @ 20°C (ohm/km)			VOLT/AMP.km (Phase to Neutral) Z1 @ 40°C (ohm/km)			VOLT/AMP.km (Phase to Neutral) Z1 @ 75°C (ohm/km)		
	0.8pf	0.9pf	0.95pf	0.8pf	0.9pf	0.95pf	0.8pf	0.9pf	0.95pf
Imperial (inches)									
7/.044 4WL HD	2.3386	2.5392	2.6236	2.4993	2.7200	2.8144	2.7805	3.0363	3.1483
7/.044 2CTW HD	4.2170	4.7441	5.0076	4.5383	5.1056	5.3892	5.1006	5.7382	6.0570
7/.044 4CTW HD	2.1085	2.3720	2.5038	2.2691	2.5528	2.6946	2.5503	2.8691	3.0285
7/.064 4WL HD	1.2125	1.2780	1.2958	1.2885	1.3634	1.3859	1.4214	1.5129	1.5437
7/.064 2CTW HD	1.9930	2.2421	2.3666	2.1448	2.4129	2.5470	2.4106	2.7119	2.8626
7/.064 4CTW HD	0.9965	1.1210	1.1833	1.0724	1.2065	1.2735	1.2053	1.3560	1.4313
37/.083 4WL	0.2783	0.2445	0.2156	0.2864	0.2536	0.2253	0.3005	0.2695	0.2421
Metric (mm)									
7/1.35 4WL	1.7261	1.8529	1.9009	1.8406	1.9818	2.0369	2.0410	2.2073	2.2749
7/1.35 2CTW	3.1141	3.4603	3.6259	3.3431	3.7180	3.8979	3.7440	4.1690	4.3740
7/1.35 4CTW	1.5270	1.7084	1.7973	1.6416	1.8372	1.9334	1.8420	2.0627	2.1714
7/1.70 4WL	1.1263	1.1817	1.1945	1.1958	1.2599	1.2771	1.3174	1.3967	1.4215
7/1.70 2CTW	1.9200	2.1217	2.2160	2.0590	2.2781	2.3810	2.3022	2.5517	2.6698
7/1.70 4CTW	0.9300	1.0391	1.0924	0.9995	1.1173	1.1749	1.1211	1.2541	1.3193
19/1.35 4WL	0.7353	0.7466	0.7383	0.7759	0.7923	0.7865	0.8470	0.8723	0.8709
19/1.53 4WL	0.6128	0.6107	0.5960	0.6445	0.6463	0.6336	0.6999	0.7086	0.6994
19/2.14 4WL	0.3971	0.3731	0.3483	0.4133	0.3913	0.3675	0.4416	0.4232	0.4011

Notes:
1. 4WL = 4 wire lateral service (3 phase + neutral), spaced 300mm apart.
2. 2CTW = 2 core twisted service (1 phase + neutral).
3. 4CTW = 4 core twisted service (3 phase + neutral).
4. HD = Hard Drawn
5. Voltage drops are phase to neutral.
6. For single phase supplies voltage drop figures have been multiplied by 2 so that voltage drops are phase to neutral including the voltage drop on the neutral conductor. For 3 phase supplies the voltage drops are phase to neutral excluding any voltage drop on the neutral conductor.

Calculations: Voltage Drop

Top Of This Section

Contents - Overhead Conductors - Service Conductors
Conductor Impedance
Voltage Drop
Conductor Ratings

CONDUCTOR COPPER	SUMMER DAY (amps)	WINTER NIGHT (amps)
Imperial:		
7/.044 4WL	89	91
7/.044 2CTW	89	79
7/.044 4CTW	65	64
7/.064 4WL	130	135
7/.064 2CTW	130	120
7/.064 4CTW	94	99
37/.083 4WL	495	570
Metric:		
7/1.35 4WL	105	105
7/1.35 2CTW	105	93
7/1.35 4CTW	76	76
7/1.70 4WL	140	145
7/1.70 2CTW	140	125
7/1.70 4CTW	100	105
19/1.35 4WL	190	205
19/1.53 4WL	225	240
19/2.14 4WL	335	370

Notes:
1. 4WL = 4 wire lateral service (3 phase + neutral), spaced 300mm. apart.
2. 2CTW = 2 core twisted service (1 phase + neutral).
3. 4CTW = 4 core twisted service (3 phase + neutral).
4. Maximum conductor temperature : 75°C
5. Values are rounded to nearest 1A for values below 100, rounded to nearest 5A for values above 100.
6. Environmental Conditions:

Condition	Ambient Temperature (Ta) (°C)	Solar Radiation Intensity (W/m^2)	Wind Velocity (m/s)
Summer Day	35	1000	1.0
Winter Night	10	0	0.0

Top Of This Section

HV NETWORK FEEDER RATINGS

Procedure for feeder rating determination

Feeder rating table

Contents

PROCEDURE FOR FEEDER RATING DETERMINATION

Contents - Feeder Ratings Section

OBJECTIVE

To define the HV feeder ratings for network planning, protection and operations.

SCOPE

This procedure applies to feeder rating review, network planning, network protection, and network operations. Feeder ratings, firm factor, load category, and feeder type are defined in this document.

FEEDER RATING DETERMINATION METHOD

Cable rating calculation method

HV cable ratings are calculated from the base ratings provided by the manufacturers and de-rating factors from manufacturer manuals and Australian Standard AS4026. The following factors are taken into account in the calculation

- Cable construction
- Installation method
- Ground temperature and soil thermal resistivity
- Load characteristics
- Seasonal and cyclic de-rating effect
- Group de-rating effect

The calculation result is incorporated in Procedure EN4.4 P10 Electrical Data Manual.

Feeder Thermal Rating Determination Method

Individual feeder ratings are determined by cable ratings and individual installation and network configuration conditions. When determining feeder ratings, the following steps are followed

- Exam feeder section from zone substation to the first few distribution substations or switch stations to identify up to two rating limiting locations;
- Identify feeder constructions and sizes;
- Determine the number of effective cables a group. The number of effective cables are determined by cable loading limit and the thermal effect on surrounding soil;
- Determine the effect of conduits. The effect of conduits used for road crossing in cable installation is ignored;
- Determine feeder load profiles (i.e. domestic or commercial/industrial) for winter and summer peaks;
- Get the appropriate figures from cable ratings listed in EN4.4.
- Adjust rating figures by network configuration factors, such as upstream substations and feeder branches

Feeder firm rating determination method

Feeder firm rating factor is determined by the number of effective feeder ties. In case of a permanent feeder fault close to zone substation, the effective feeder ties shall allow even transfer of the feeder's load to adjacent feeders. Firm factors are determined by the table below:

Number of effective ties	Firm Factor
Nil	1.0
1	0.5
2 or more	0.75

Firm rating is calculated as thermal rating times firm factor.

FEEDER AND LOAD CLASSIFICATION

Feeder load category

Feeders load classified into two categorised: domestic load and commercial/industrial load.

Domestic load is defined as having distinct morning and evening peaks, typically from 7am to 9am, and 6pm to10pm, and lower load between the two peaks.

Commercial and industrial load typically has peak load during business hours, generally from 9am to 5pm.

Feeder classification

Feeders are classified as overhead feeders or underground feeders. This classification is intended for protection settings.

A feeder with 200 metres or more of OH conductors is classified as OH feeder that requires SEF protection. A feeder with less than 200 metres of OH conductors is defined as UG feeder.

It is to be noted that the current protection standard also requires that feeders with more than 20% of OH conductors be fitted with auto reclose relays or SCADA auto reclose function.

APPLICATION

The feeder ratings are applicable to System Control. All feeder loads shall be maintained below their seasonal thermal ratings in any operating conditions.

Feeder thermal and firm ratings are applicable to Network Planning in network capacity assessment and augmentations.

Feeder installation classification is applicable to Protection in the application of feeder protection settings.

REFERENCES

- Australian Standard AS4026
- EN4.4 P10 Electrical Data Manual
- Manufacturer cables data manuals
- ACTEWAGL-#213082-EN 4.4 P07 - Distribution Network Reliability & Standard Supply Arrangements

Top Of This Section

Feeder Rating Table

Contents - Feeder Ratings Section

Zone	Name of	Zone	Feeder Length in km			Feeder	Load Category		Firm	Winter		Summer	
Substation	11 kV Feeder	CB	UG	OH	Total	Type	Winter	Summer	Factor	Thermal	Firm	Thermal	Firm
Angle Crossing	HLPS		1.600	0.000	1.600	UG	COM	COM	1.00	585	585	525	525
Belconnen	Aikman	8KB	4.500	0.000	4.500	UG	COM	COM	0.75	325	244	290	218
Belconnen	Baldwin	8PB	5.909	3.837	9.746	OH	DOM	DOM	0.75	365	274	325	244
Belconnen	Battye	8XB	4.717	3.254	7.971	OH	DOM	DOM	0.75	365	274	325	244
Belconnen	Bean	8+GB	7.132	1.485	8.617	OH	DOM	DOM	0.75	355	266	315	236
Belconnen	Benjamin	8FB	5.211	0.000	5.211	UG	COM	COM	0.75	325	244	290	218
Belconnen	CAE No. 1	8DB	0.000	0.000	0.000	OH	COM	COM	0.75	325	244	290	218
Belconnen	CAE No. 2	8EB	6.414	3.730	10.144	UG	COM	COM	0.75	325	244	290	218
Belconnen	Cameron North	8MB	3.429	0.000	3.429	UG	COM	COM	0.75	380	285	340	255
Belconnen	Cameron South	8GB	5.614	0.000	5.614	UG	COM	COM	0.75	325	244	290	218
Belconnen	Chan	8+HB	3.469	0.000	3.469	UG	COM	COM	0.75	335	251	300	225
Belconnen	Chandler	8LB	2.567	0.000	2.567	UG	COM	COM	0.75	325	244	290	218
Belconnen	Chuculba	8RB	8.347	4.912	13.259	OH	DOM	DOM	0.75	365	274	325	244
Belconnen	Eardley	8+FB	3.637	0.899	4.536	OH	COM	COM	0.75	395	296	350	263
Belconnen	Emu Bank	8JB	4.169	0.000	4.169	UG	COM	COM	0.75	370	278	330	248
Belconnen	Haydon	8WB	9.846	7.371	17.217	OH	DOM	COM	0.75	365	274	300	225
Belconnen	Joy Cummins	8PB				UG	COM	COM	0.75	410	308	365	274
Belconnen	Lampard	8VB				UG	COM	COM	0.75	410	308	365	274
Belconnen	Laurie	8FB	7.836	1.033	8.869	OH	DOM	DOM	0.75	355	266	315	236
Belconnen	Maribyrnong	8TB	2.402	9.192	11.594	OH	IND	IND	0.75	335	251	300	225
Belconnen	McGuinnes	8NB	7.082	0.000	7.082	UG	DOM	DOM	0.75	355	266	315	236
Belconnen	Meacham	8+GB	9.733	8.635	18.368	OH	DOM	DOM	0.75	430	323	385	289
Belconnen	Shannon	8UB	10.343	7.936	18.279	OH	DOM	DOM	0.75	405	304	360	270
Belconnen	Swinden	8VB	7.498	13.674	21.172	OH	DOM	COM	0.75	365	274	300	225
Belconnen	William Slim	8QB	9.232	5.729	14.961	OH	DOM	DOM	0.75	355	266	315	236
City East	Aero Park	8+UB	7.200	0.000	7.200	UG	COM	COM	0.75	395	296	350	263
City East	Ainslie	8+EB	2.636	0.000	2.636	UG	COM	COM	0.75	345	259	310	233
City East	Akuna	8NB	3.062	0.000	3.062	UG	COM	COM	0.75	345	259	310	233
City East	Allara	8UB	4.055	0.000	4.055	UG	COM	COM	0.75	345	259	310	233
City East	Binara	8+PB	3.000	0.000	3.000	UG	COM	COM	0.75	380	285	340	255
City East	Braddon	8+NB	3.600	0.000	3.600	UG	COM	COM	0.75	380	285	340	255
City East	Bunda	8+FB	4.827	0.000	4.827	UG	COM	COM	0.75	345	259	310	233
City East	Chisholm	8KB	2.748	4.050	6.798	OH	DOM	DOM	0.75	405	304	360	270
City East	CNBP2	8PB	4.227	0.000	4.227	UG	COM	COM	1.00	355	355	315	315
City East	Constitution	8RB	3.267	0.000	3.267	UG	COM	COM	0.5	370	185	330	165
City East	Cooyong	8TB	3.719	0.000	3.719	UG	COM	COM	0.75	370	278	330	248
City East	Cowper	8SB	11.012	3.443	14.455	OH	DOM	COM	0.75	340	255	285	214
City East	Duffy	8XB	7.098	14.770	21.868	OH	DOM	DOM	0.75	325	244	290	218
City East	Ebden	8LB	2.057	7.299	9.356	OH	DOM	DOM	0.75	405	304	360	270
City East	Electricity House	8HB	3.557	0.000	3.557	UG	COM	COM	0.75	370	278	330	248
City East	Fairbairn	8DB	2.069	5.435	7.504	OH	COM	COM	0.75	395	296	350	263
City East	Ferdinand	OH	7.037	7.477	14.514	OH	DOM	DOM	0.75	430	323	385	289
City East	Haig	8+LB	5.078	0.000	5.078	UG	DOM	COM	0.75	435	326	365	274
City East	Ijong	8+TB	4.992	0.000	4.992	UG	DOM	COM	0.75	350	263	285	214
City East	Lonsdale	8+MB	3.879	0.000	3.879	UG	COM	COM	0.75	420	315	380	285
City East	Mackenzie	8YB	4.114	24.207	28.321	OH	DOM	DOM	0.75	415	311	370	278
City East	Masson	8+SB	2.799	0.000	2.799	UG	COM	COM	0.75	375	281	335	251

Zone	Name of	Zone	Feeder Length in km			Feeder	Load Category		Firm	Winter		Summer	
Substation	11 kV Feeder	CB	UG	OH	Total	Type	Winter	Summer	Factor	Thermal	Firm	Thermal	Firm
City East	Northbourne	8+RB	4.645	0.000	4.645	UG	COM	COM	0.75	310	233	280	210
City East	Petrie	8JB	3.343	0.000	3.343	UG	COM	COM	0.75	370	278	330	248
City East	Quick	8GB	5.440	0.253	5.693	OH	DOM	COM	0.75	305	229	250	188
City East	Stott	8VB	4.026	6.668	10.694	OH	DOM	DOM	0.75	335	251	300	225
City East	Wakefield	8WB	3.330	2.838	6.168	OH	DOM	DOM	0.75	350	263	310	233
City East	Wolseley	8FB	5.657	2.079	7.736	OH	DOM	DOM	0.75	350	263	310	233
Civic	ANU No1	8EB	0.932	0.000	0.932	UG	COM	COM	0.80	375	300	335	268
Civic	ANU No2	8JB	0.933	0.000	0.933	UG	COM	COM	0.80	335	268	300	240
Civic	ANU No3	8+EB	1.229	0.000	1.229	UG	COM	COM	0.80	335	268	300	240
Civic	ANU No4	8GB	1.227	0.000	1.227	UG	COM	COM	0.80	375	300	335	268
Civic	ANU No5	8WB	1.299	0.000	1.299	UG	COM	COM	0.80	347	278	389	311
Civic	Belconnen Way North	8LB	3.443	9.804	13.247	OH	DOM	COM	0.75	410	308	335	251
Civic	Belconnen Way South	8DB	7.385	7.654	15.039	OH	DOM	DOM	0.75	425	319	375	281
Civic	Black Mountain	8YB				OH	DOM	DOM	0.75	385	289	345	259
Civic	Christian	8XB	2.949	1.002	3.951	OH	COM	COM	0.5	310	155	275	138
Civic	CSIRO	8KB	2.617	0.000	2.617	UG	COM	COM	0.75	340	255	305	229
Civic	Dryandra	8+DB	2.395	6.395	8.790	OH	COM	COM	0.75	375	281	315	236
Civic	Girraween	8RB	3.399	0.000	3.399	UG	COM	COM	0.75	340	255	305	229
Civic	Hobart Long	8NB	6.502	0.000	6.502	UG	COM	COM	0.75	340	255	305	229
Civic	Hobart Short	8FB	3.302	0.000	3.302	UG	COM	COM	0.75	375	281	335	251
Civic	Jolimont	8PB	3.440	0.000	3.440	UG	COM	COM	0.75	340	255	305	229
Civic	McCaughey	8QB	5.393	3.743	9.136	OH	COM	COM	0.75	340	255	305	229
Civic	Miller	8VB	4.175	15.332	19.507	OH	DOM	DOM	0.75	410	308	365	274
Civic	Nicholson	8MB				UG	COM	COM	0.75	410	308	365	274
Civic	Telecom Tower	8UB	1.407	0.000	1.407	UG	COM	COM	0.5	375	188	335	168
Civic	Wattle	8TB	7.162	0.301	7.463	OH	DOM	DOM	0.75	410	308	365	274
Fyshwick	Abbattoirs	8HB	1.364	21.090	22.454	OH	IND	IND	0.75	400	300	355	266
Fyshwick	Airport	8PB	4.999	0.000	4.999	UG	COM	COM	0.75	395	296	350	263
Fyshwick	Barrier	8KB	0.509	2.659	3.168	OH	IND	IND	0.75	345	259	310	233
Fyshwick	Collie	8MB	0.325	2.351	2.676	OH	IND	IND	0.75	345	259	310	233
Fyshwick	Domayne	8DB	2.764	1.819	4.583	OH	COM	COM	0.75	450	338	400	300
Fyshwick	Gladstone	8MB	1.408	2.732	4.140	OH	COM	COM	0.75	395	296	350	263
Fyshwick	Newcastle	8NB	1.465	12.506	13.971	OH	COM	COM	0.75	370	278	330	248
Fyshwick	Pialligo	8FB				UG	COM	COM	0.75	410	308	365	274
Fyshwick	Tennant	8EB	0.436	2.315	2.751	OH	IND	IND	0.75	345	259	310	233
Fyshwick	Whyalla	8FB	1.737	4.802	6.539	OH	IND	IND	0.75	370	278	330	248
Gilmore	Alderson	8FB	1.336	11.833	13.169	OH	IND	IND	0.75	400	300	355	266
Gilmore	Beggs	8LB	7.833	1.136	8.969	OH	DOM	DOM	0.75	400	300	360	270
Gilmore	Edmond	8+PB	8.541	0.978	9.519	OH	DOM	DOM	0.75	400	300	360	270
Gilmore	Falkiner	8MB	7.099	1.382	8.481	OH	DOM	DOM	0.75	400	300	360	270
Gilmore	Findlayson	8+RB	10.596	0.301	10.897	OH	DOM	DOM	0.75	400	300	360	270
Gilmore	Harman	8GB	9.200	0.000	9.200	UG	COM	COM	1.0	705	705	625	625
Gilmore	Jackie Howe	8JB	10.805	1.067	11.872	OH	DOM	DOM	0.75	400	300	360	270
Gilmore	May Maxwell	8+SB	7.296	1.033	8.329	OH	DOM	DOM	0.75	400	300	360	270
Gilmore	Monaro	8HB	2.786	12.430	15.216	OH	IND	IND	0.75	420	315	375	281
Gilmore	Penton	8+NB	5.437	0.000	5.437	UG	DOM	DOM	0.75	400	300	360	270
Gilmore	Rossman	8+TB	6.576	2.252	8.828	OH	DOM	DOM	0.75	400	300	360	270
Gilmore	Tralee	8NB	2.1	0	2.1	UG	COM	COM	0.75	380	285	340	255
Gilmore	Willoughby	8+MB	7.678	0.897	8.575	OH	DOM	DOM	0.75	400	300	360	270
Gold Creek	Anthony Rofle	8NB	7.929	0.000	7.929	UG	DOM	DOM	0.75	460	345	410	308

Zone	Name of	Zone	Feeder Length in km			Feeder	Load Category		Firm	Winter		Summer	
Substation	11 kV Feeder	CB	UG	OH	Total	Type	Winter	Summer	Factor	Thermal	Firm	Thermal	Firm
Gold Creek	Barrington	8+UB	6.434	0.000	6.434	UG	DOM	DOM	0.75	430	323	385	289
Gold Creek	Birragai	8+MB	3.748	0.000	3.748	UG	DOM	DOM	0.75	430	323	385	289
Gold Creek	Boulevarde North	8+RB	3.891	0.000	3.891	UG	COM	COM	0.75	395	296	350	263
Gold Creek	Bunburung	8+PB	2.028	0.000	2.028	UG	DOM	DOM	0.75	430	323	385	289
Gold Creek	Ferguson	8EB	15.682	0.000	15.682	UG	DOM	DOM	0.75	430	323	385	289
Gold Creek	Gribble	8EB	2.940	0.000	2.940	UG	COM	COM	0.75	395	296	350	263
Gold Creek	Gungahlin	8GB	3.948	9.565	13.513	OH	COM	COM	0.75	395	296	350	263
Gold Creek	Gurrang	8+KB	2.442	1.642	4.084	OH	DOM	DOM	0.75	430	323	385	289
Gold Creek	Hughes	8JB	4.438	0.000	4.438	UG	DOM	DOM	0.75	430	323	385	289
Gold Creek	Lander	8PB	2.803	0.000	2.803	UG	DOM	DOM	0.75	430	323	385	289
Gold Creek	Lexcen	8HB	16.356	0.000	16.356	UG	DOM	DOM	0.75	430	323	385	289
Gold Creek	Ling	8LB	1.017	0.000	1.017	UG	DOM	DOM	0.75	430	323	385	289
Gold Creek	Magenta	8+SB	3.681	0.000	3.681	UG	DOM	DOM	0.75	430	323	385	289
Gold Creek	Nona	8+VB	1.573	0.000	1.573	UG	DOM	DOM	0.75	430	323	385	289
Gold Creek	Riley	8+TB	2.605	0.000	2.605	UG	DOM	DOM	0.75	430	323	385	289
Gold Creek	Saunders	8FB	4.224	0.000	4.224	UG	DOM	DOM	0.75	430	323	385	289
Gold Creek	Wanganeen	8+NB	3.330	0.000	3.330	UG	DOM	DOM	0.5	430	215	385	193
Gold Creek	Wellington	8+LB	0.885	0.000	0.885	UG	DOM	DOM	0.5	430	215	385	193
Gold Creek	West	8MB	12.803	8.547	21.350	OH	DOM	DOM	0.75	430	323	385	289
Latham	Bowley	8WB	9.160	6.823	15.983	OH	DOM	DOM	0.75	345	259	310	233
Latham	Conley	8+GB	3.292	4.189	7.481	OH	DOM	DOM	0.75	430	323	385	289
Latham	Copland	8+PB	5.629	6.726	12.355	OH	DOM	DOM	0.75	385	289	345	259
Latham	Elkington	8VB	7.875	2.549	10.424	OH	DOM	DOM	0.75	345	259	310	233
Latham	Fielder	8+PB	5.569	7.059	12.628	OH	DOM	COM	0.75	410	308	335	251
Latham	Florey	8GB	3.722	3.508	7.230	OH	DOM	DOM	0.75	350	263	310	233
Latham	Homann	8DB	3.404	18.359	21.763	OH	DOM	DOM	0.75	350	263	310	233
Latham	Latham	8KB	2.280	5.830	8.110	OH	DOM	DOM	0.75	350	263	310	233
Latham	Lhotsky	8FB	14.479	11.293	25.772	OH	DOM	DOM	0.75	350	263	310	233
Latham	Low Molonglo East	8RB	6.813	3.932	10.745	OH	DOM	COM	0.5	345	173	280	140
Latham	Low Molonglo West	8TB	6.628	7.985	14.613	OH	DOM	COM	0.5	345	173	280	140
Latham	Macrossan	8JB	3.473	29.340	32.813	OH	DOM	DOM	0.75	350	263	310	233
Latham	Markell	8+LB	8.971	2.691	11.662	OH	DOM	DOM	0.75	380	285	335	251
Latham	Melba	8+HB	2.913	5.751	8.664	OH	DOM	DOM	0.75	430	323	385	289
Latham	OLoghlen	8LB	5.038	4.041	9.079	OH	DOM	DOM	0.75	350	263	310	233
Latham	Paterick	8NB	6.211	2.183	8.394	OH	DOM	DOM	0.75	345	259	310	233
Latham	Powers	8MB	5.081	3.505	8.586	OH	DOM	DOM	0.75	350	263	310	233
Latham	Seal	8QB	4.666	3.213	7.879	OH	DOM	DOM	0.75	345	259	310	233
Latham	Tillyard	8EB	6.682	0.906	7.588	OH	DOM	DOM	0.75	350	263	310	233
Latham	Verbrugghen	8+NB	5.376	4.749	10.125	OH	DOM	DOM	0.75	410	308	365	274
Latham	Weir	8PB	4.519	6.388	10.907	OH	DOM	DOM	0.75	345	259	310	233
Telopea Park	ANU Backup	8+FB	7.533	0.000	7.533	UG	COM	COM	0.75	270	203	240	180
Telopea Park	Belmore	8+FB	5.372	0.251	5.623	OH	DOM	DOM	0.75	285	214	255	191
Telopea Park	Blackall	8QB	2.121	0.000	2.121	UG	COM	COM	0.75	345	259	310	233
Telopea Park	Bowen	8MB	11.159	0.000	11.159	UG	COM	COM	0.75	430	323	385	289
Telopea Park	Brisbane	8+DB	5.008	0.247	5.255	OH	COM	COM	0.75	265	199	235	176
Telopea Park	Broughton	8+EB	4.536	0.000	4.536	UG	COM	COM	0.75	265	199	235	176
Telopea Park	CNBP1	8SB				UG	COM	COM	0.75	410	308	365	274
Telopea Park	Cunningham	8+LB	4.034	6.223	10.257	OH	DOM	DOM	0.75	430	323	385	289
Telopea Park	Edmond Barton	8NB	5.546	0.000	5.546	UG	COM	COM	0.75	265	199	235	176
Telopea Park	Empire	8TB	8.622	2.603	11.225	OH	DOM	DOM	0.75	305	229	270	203

Zone	Name of	Zone	Feeder Length in km			Feeder	Load Category		Firm	Winter		Summer	
Substation	11 kV Feeder	CB	UG	OH	Total	Type	Winter	Summer	Factor	Thermal	Firm	Thermal	Firm
Telopea Park	Forster	8+HB	2.800	0.000	2.800	UG	COM	COM	0.75	385	289	345	259
Telopea Park	Gallery	8+RB	2.987	0.000	2.987	UG	COM	COM	0.75	265	199	235	176
Telopea Park	Giles	8VB	5.928	5.143	11.071	OH	DOM	DOM	0.75	290	218	260	195
Telopea Park	Jardine	8+SB	3.159	0.123	3.282	UG	DOM	DOM	0.75	380	285	335	251
Telopea Park	Kelliher	8PB	3.483	2.964	6.447	OH	COM	COM	0.75	400	300	355	266
Telopea Park	Kingston Foreshore 1	8+JB	0.756	0.000	0.756	UG	DOM	DOM	0.75	470	353	420	315
Telopea Park	Kurrajong	8HB	3.823	0.000	3.823	UG	COM	COM	0.75	265	199	235	176
Telopea Park	Mildura	8+PB	4.867	0.000	4.867	UG	COM	COM	0.75	295	221	265	199
Telopea Park	Monash	8GB	12.187	44.047	56.234	OH	DOM	COM	0.75	400	300	355	266
Telopea Park	Mundaring	8FB	10.275	10.449	20.724	OH	DOM	COM	0.75	400	300	355	266
Telopea Park	NSW	8UB	10.996	2.708	13.704	OH	DOM	DOM	0.75	370	278	330	248
Telopea Park	Ovens	8+KB	5.257	5.144	10.401	OH	DOM	DOM	0.75	365	274	325	244
Telopea Park	Parliament Hse No 1	8+TB	3.958	0.000	3.958	UG	COM	COM	0.75	380	285	340	255
Telopea Park	Parliament Hse No 4	8+GB	3.189	0.000	3.189	UG	COM	COM	0.75	400	300	355	266
Telopea Park	Power House	8+VB	1.123	5.697	6.820	OH	COM	COM	0.75	320	240	285	214
Telopea Park	Queen Victoria	8JB	2.847	0.000	2.847	UG	COM	COM	0.75	345	259	310	233
Telopea Park	Riverside	8WB	7.043	0.000	7.043	UG	COM	COM	0.75	265	199	235	176
Telopea Park	Russell No1	8LB	6.156	0.000	6.156	UG	COM	COM	0.75	345	259	310	233
Telopea Park	Russell No2	8XB	2.578	0.000	2.578	UG	COM	COM	0.75	345	259	310	233
Telopea Park	Russell No3	8FB				UG	COM	COM	0.75	410	308	365	274
Telopea Park	Sandalwood	8EB	3.883	7.356	11.239	OH	IND	IND	0.75	435	326	385	289
Telopea Park	Strzelecki	8+MB	6.189	3.855	10.044	OH	DOM	DOM	0.75	430	323	385	289
Telopea Park	Sturt	8+NB	5.980	3.287	9.267	OH	DOM	DOM	0.75	320	240	285	214
Telopea Park	Telopea Park East	8+UB	2.940	0.000	2.940	UG	DOM	COM	0.75	290	218	240	180
Telopea Park	Throsby	8+WB	1.015	0.000	1.015	UG	DOM	DOM	0.75	380	285	335	251
Telopea Park	Yorkpark No1	8DB	1.696	0.000	1.696	UG	COM	COM	0.75	395	296	350	263
Telopea Park	Yorkpark No2	8RB	1.606	0.000	1.606	UG	COM	COM	0.75	395	296	350	263
Telopea Park	Young	8ZB	3.492	0.000	3.492	UG	COM	COM	0.75	265	199	235	176
Theodore	Banyule	8GB	12.577	0.498	13.075	OH	DOM	DOM	0.75	400	300	360	270
Theodore	Callister	8+RB	14.239	1.215	15.454	OH	DOM	DOM	0.75	400	300	360	270
Theodore	Chippindall	8+SB	12.285	0.452	12.737	OH	DOM	DOM	0.75	400	300	360	270
Theodore	Eaglemont	8FB	10.500	0.000	10.500	UG	DOM	DOM	0.75	400	300	360	270
Theodore	Fairley	8+UB	6.799	48.449	55.248	OH	DOM	DOM	0.75	430	323	385	289
Theodore	Lawrence Wackett	8+TB	10.678	0.000	10.678	UG	DOM	DOM	0.75	400	300	360	270
Theodore	Lethbridge	8+JB	9.007	0.066	9.073	UG	DOM	DOM	0.75	400	300	360	270
Theodore	Morison	8GB	10.326	0.000	10.326	UG	DOM	DOM	0.75	400	300	360	270
Theodore	Templestowe	8LB	6.318	0.000	6.318	UG	DOM	DOM	0.75	400	300	360	270
Wanniassa	Ashley	8NB	9.045	0.000	9.045	UG	DOM	DOM	0.75	365	274	325	244
Wanniassa	Athllon	8+FB	8.083	6.084	14.167	OH	DOM	DOM	0.75	435	326	390	293
Wanniassa	Bissenberger	8KB	10.483	3.072	13.555	OH	DOM	DOM	0.75	400	300	360	270
Wanniassa	Brookman	8+MB	1.255	8.016	9.271	OH	DOM	DOM	0.75	435	326	390	293
Wanniassa	Conolly	8+GB	5.448	2.498	7.946	OH	DOM	COM	0.75	380	285	310	233
Wanniassa	Erindale	8+HB	7.985	0.000	7.985	UG	COM	COM	0.75	345	259	310	233
Wanniassa	Fincham	8LB	12.558	0.345	12.903	OH	DOM	DOM	0.75	365	274	325	244
Wanniassa	Gaunson	8SB	6.984	0.000	6.984	UG	DOM	DOM	0.75	380	285	335	251
Wanniassa	Gouger	8+NB	1.865	5.901	7.766	OH	DOM	DOM	0.75	400	300	360	270
Wanniassa	Grimshaw	8ZB	13.984	0.000	13.984	UG	DOM	DOM	0.75	380	285	335	251
Wanniassa	Hawker	8+LB	0.378	6.516	6.894	OH	DOM	DOM	0.75	400	300	360	270
Wanniassa	Hawkesbury	8KB	4.488	9.256	13.744	OH	DOM	DOM	0.75	435	326	390	293
Wanniassa	Hemmings	8QB	11.813	1.149	12.962	OH	DOM	DOM	0.75	380	285	335	251

Zone	Name of	Zone	Feeder Length in km			Feeder	Load Category		Firm	Winter		Summer	
Substation	11 kV Feeder	CB	UG	OH	Total	Type	Winter	Summer	Factor	Thermal	Firm	Thermal	Firm
Wanniassa	Lambrigg	8+PB	1.294	6.520	7.814	OH	DOM	DOM	0.75	380	285	335	251
Wanniassa	Langdon	8VB	11.493	3.246	14.739	OH	DOM	DOM	0.75	380	285	335	251
Wanniassa	Longmore	8HB	7.367	0.040	7.407	UG	DOM	DOM	0.75	380	285	335	251
Wanniassa	Mannheim	8NB	8.134	0.960	9.094	OH	DOM	DOM	0.75	335	251	300	225
Wanniassa	Marconi	8EB	10.386	1.997	12.383	OH	DOM	DOM	0.75	400	300	360	270
Wanniassa	Mathews	8JB	11.208	98.506	109.714	OH	DOM	DOM	0.75	365	274	325	244
Wanniassa	Mugga	8PB	0.960	21.680	22.640	OH	COM	COM	0.75	400	300	355	266
Wanniassa	Muresk	8MB	7.793	3.489	11.282	OH	DOM	COM	0.75	495	371	405	304
Wanniassa	Pitman	8FB	6.585	0.000	6.585	UG	COM	COM	0.75	370	278	330	248
Wanniassa	Pridham	8+LB	3.990	6.233	10.223	OH	DOM	DOM	0.75	380	285	335	251
Wanniassa	Reid	8SB	11.207	66.719	77.926	OH	DOM	DOM	0.75	400	300	360	270
Wanniassa	Rowland	8DB	7.396	0.000	7.396	UG	COM	COM	0.75	370	278	330	248
Wanniassa	Sainsbury	8UB	7.022	0.540	7.562	OH	DOM	DOM	0.75	380	285	335	251
Wanniassa	Sternberg	8+JB	8.681	0.000	8.681	UG	DOM	COM	0.75	365	274	300	225
Wanniassa	Symers	8TB	5.698	1.392	7.090	OH	DOM	DOM	0.75	380	285	335	251
Woden	Bunbury	8TB	6.397	7.476	13.873	OH	DOM	DOM	0.75	400	300	360	270
Woden	Carruthers	8+PB	2.344	7.792	10.136	OH	DOM	DOM	0.75	415	311	370	278
Woden	Cooleman	8+HB	4.878	2.641	7.519	OH	DOM	COM	0.75	385	289	315	236
Woden	Corrina	8UB	3.186	0.000	3.186	UG	COM	COM	0.75	370	278	330	248
Woden	Cotter 11kV	8SB	3.089	48.653	51.742	OH	DOM	DOM	0.75	400	300	360	270
Woden	Cotter 22kV	8JB	0.406	11.650	12.056	OH	COM	COM	0.5	295	148	265	133
Woden	Curtin North	8PB	5.820	9.467	15.287	OH	DOM	COM	0.75	385	289	315	236
Woden	Daplyn	8+GB	1.804	6.738	8.542	OH	DOM	DOM	0.75	385	289	345	259
Woden	Deakin No1	8NB	3.778	3.621	7.399	OH	DOM	COM	0.75	385	289	315	236
Woden	Deakin No2	8+TB	3.411	2.139	5.550	OH	DOM	COM	0.75	430	323	350	263
Woden	Devonport	8+TB	1.862	2.457	4.319	OH	COM	COM	0.75	420	315	375	281
Woden	Easty	8+YB	3.048	0	3.048	UG	COM	COM	0.75	355	266	315	236
Woden	Follingsby	8SB	8.086	6.542	14.628	OH	DOM	DOM	0.75	455	341	410	308
Woden	Garran	8EB	4.127	0	4.127	UG	COM	COM	0.75	355	266	315	236
Woden	Hilder	8+JB	4.861	3.179	8.040	OH	DOM	DOM	0.75	410	308	365	274
Woden	Hindmarsh	8+RB	2.042	1.621	3.663	OH	COM	COM	0.75	405	304	365	274
Woden	Kent	8+QB	3.993	0.000	3.993	UG	COM	COM	0.75	370	278	330	248
Woden	King	8+EB	4.826	1.110	5.936	OH	COM	COM	0.75	370	278	330	248
Woden	Launceston	8+SB	4.574	0.845	5.419	OH	COM	COM	0.75	370	278	330	248
Woden	Lyons West	8+UB	2.471	12.059	14.530	OH	DOM	DOM	0.75	430	323	385	289
Woden	McInnes	8+VB	4.354	5.150	9.504	OH	DOM	DOM	0.75	410	308	365	274
Woden	Phillip North	8+MB	5.500	0.311	5.811	OH	COM	COM	0.75	405	304	365	274
Woden	Phillip South	8KB	2.908	0.000	2.908	UG	COM	COM	0.75	375	281	335	251
Woden	Streeton	8+NB	4.726	2.645	7.371	OH	DOM	DOM	0.75	430	323	385	289
Woden	Theodore	8+FB	6.067	6.943	13.010	OH	DOM	DOM	0.75	415	311	370	278
Woden	Tidbinbilla 22kV	8VB	1.939	22.589	24.528	OH	COM	COM	0.5	295	148	265	133
Woden	Weston East	8+SB	7.948	6.116	14.064	OH	DOM	DOM	0.75	385	289	345	259
Woden	Wilson	8+LB	2.119	7.545	9.664	OH	DOM	DOM	0.75	415	311	370	278
Woden	Yamba	8RB	5.476	0.000	5.476	UG	COM	COM	0.75	370	278	330	248
Woden	Yarralumla	8FB	4.395	11.118	15.513	OH	DOM	DOM	0.75	380	285	335	251

Top Of The Table

DISTRIBUTION SUBSTATION PARAMETERS

The data contained in the tables below has been extracted from period contract PC 5/2000 with ABB and Schneider.

COMMON SPECIFICATIONS

No Load Voltage ratio	11kV/433V
Vector Group	Dyn1
Tapping Range steps:	7
Tapping range steps:	+10% to -5%
Insulation Level of HV windings	95kV 28kV

PARTICULAR TECHNICAL SPECIFICATIONS FOR *GROUND MOUNTED* TRANSFORMERS[1]	**500 kVA**	**750 kVA**	**1000 kVA**
Full load losses at 75 Deg C (Wc) - Guaranteed	3.056kW	4.686kW	5.610kW
No load loss (Wi) - Guaranteed	0.747kW	1.029kW	1.303kW
Impedance Guaranteed (%)	4	5	5
Rating of each LV phase bushing (Amps)	1000A	1600A	1600A
Rating of each LV neutral bushing (Amps)	1000A	1600A	1600A

Notes:

[1] – Sourced from ABB.

Any specifications hereafter, relating to 315kVA and 500kVA padmount transformers are data provided by ABB, and 750kVA and 1000kVA are by Schneider.

	ABB		**Schneider**	
TECHNICAL SPECIFICATIONS FOR *PADMOUNT* SUBSTATION TRANSFORMERS	**315kVA**	**500kVA**	**750kVA**	**1000kVA**
Full load losses at 75 Deg C (Wc) - Guaranteed	2.475kW	3.297kW	6.615kW	8.1kW
No load loss (Wi) - Guaranteed	0.453kW	0.663kW	1.09kW	1.285kW
Impedance voltage Guaranteed	4%	4%	5%	5%
Rating of each LV phase bushing	500A	1000A	1600A	1600A
Rating of each LV neutral bushing	200A	500A	1600A	1600A

COMMON TECHNICAL SPECIFICATIONS: HV SWITCHGEAR AND HV SWITCHGEAR TO TRANSFORMER TAILS FOR PADMOUNT SUBSTATIONS 315KVA, 500KVA, 750KVA AND 1000KVA

	ABB		**Schneider**	
	3 Way	**4 Way**	**3 Way**	**4 Way**
High Voltage Switchgear: Make Model Insulation Medium/Type (if applicable)	 ABB Safelink SF6	 Holec MD406 Resin	 Schneider RM6 130	 Schneider RM6 131
Rated Impulse Withstand to earth and between phases	95kV	95kV	95 kV	95 kV
Rated Impulse Withstand across isolation distance	110kV	95kV	110 kV	110 kV
Rated 1 minute Power Withstand to earth and between phases	28kV	28kV	28 kV	28 kV

Rated 1 minute Power Withstand across isolation	32kV	32kV	32 kV	32 kV
DC Withstand Voltage: between phases 15 min	40kV	34kV	42 kV	42 kV
DC Withstand Voltage: phases to earth for 15 minutes	40kV	25kV	N/A	N/A
Rated Normal Current of Switchboard busbars	630A	400A	630 A	630 A
Rated 1 second Withstand Current for busbars	20kA (3 sec)	14.4kA	25 kA	25 kA
Rated Peak Withstand Current for busbars	50kA	31kA	62.5 kA	62.5 kA
Feeder Load Break switch				
Rated Normal Current	630A	400A	630 A	630 A
Rated short time withstand current (1 second)	20kA (3 sec)	14.4kA	25 kA	25 kA
Rated peak withstand current	50kA	31kA	62.5 kA	62.5 kA
Rated short circuit making current	50kA	31kA	62.5 kA	62.5 kA
Number of switch operations before inspection or maintenance is required at rated normal current.	100	Dependent on site conditions	120	120
Number of switch operations permissible before inspection or maintenance is required at rated **making** current.	5	To be advised	5	5
Transformer Tee-off Fuse/Load Break Switch				
Switch Rated Normal Current	200A	400A	200 A	200 A
Switch Rated Load Break Current	N/A	400A	25 kA	25 kA
Rated short circuit making current	50kA	31kA	62.5 kA	62.5 kA
Type (DIN/BS) and Size (mm) of fuse links that fuse holder will accommodate	DIN 292	DIN 358 x 76	DIN 292	DIN 292
Fault Make Earth Switches				
Rated short time withstand current (1 second)	20kA (3 sec)	14.4kA	25 kA	25 kA
Rated peak withstand current	50kA	31kA	62.5 kA	62.5 kA
HV Switchgear to Transformer Tails				
HV Switchgear to Transformer Tails current rating	N/A	103A	200A	200A
Provision for Remote Monitoring & Operation of HV Switches				
Feeder Load Break Switch rewind motor gearbox units suitable/unsuitable for Purchaser to retrofit	N/A	N/A	Suitable	Suitable
Current Transformers for monitoring load in Feeder Circuits suitable/unsuitable for Purchaser to retrofit	N/A	N/A	Suitable	Suitable

TECHNICAL SPECIFICATIONS FOR PADMOUNT SUBSTATION LV SWITCHGEAR AND LV SWITCHGEAR TO TRANSFORMER TAILS	ABB (315k and 500kVA)	Schneider (750k and 1000kVA)
Switchboard busbar		
Rated busbar operational current	Rated kVA + 50%	Rated kVA + 50%
Busbar rated short time withstand current (1 sec)	35 kA	35/70 kA
Transformer Disconnector		
Rated Operational Current (I_e)	1000A	2000A
Rated Making Capacity (I)	1500A	N/A
Rated Breaking Capacity (Ic)	1500A	N/A
Rated short time withstand (I_{cw})	15kA	50 kA
Recommended maximum operational current for 60 degree	900A	1920 A
All three phases switched simultaneously	No	No

Feeder (DIN) Fuse-Disconnector	630A	1000A	1250A
Rated Operational Current (I_e)	630 A	1000A	1250A
Rated Making Capacity (I)	950A/1890 A **(1)**	1500A	3750A
Rated Breaking Capacity (I_c)	950A/1890 A **(1)**	1500A	3750A
Rated Conditional Short Circuit Current	50 kA	50kA	112kA
Rated Short Time Withstand (I_{cw})	15 kA	15kA	15kA
Recommended Operational Current De-rating for 60Deg	400 A	630A	1000A
Maximum fuse rating for 60Deg ambient	630 A	630A	1250A

Note:

(1): Feeder (DIN) Fuse-Disconnector ratings identical for both transformers except for Making and Breaking current, where ABB defines as 950A and Schneider 1890A respectively.

ACB (Schneider only)	2000A	1250A
Rated Continuous Current	2000 A	1250A
Rated short time withstand (I_{cw})	55 kA	65kA
Rated short-circuit making (I_{cm})	120 kA	140kA
Rated ultimate short-circuit breaking (I_{cu})	55 kA	65kA
Rated service short-circuit breaking capacity (I_{cu})	55 kA	65kA
Power frequency voltage withstand	3 kV	3kV
Insulation resistance at 1kV DC	50 MΩ	50MΩ
Impulse voltage withstand (1.2/50 microsec wave)	8 kV	8kV
Number of rated breaking operations before maintenance	2000	2000
Number of rated breaking operations before change	2000	2000

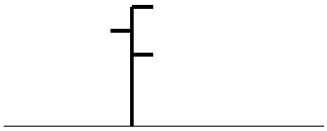
Top of this section

RESERVATIONS AND EASEMENTS

132 KV RESERVATION RECOMMENDATIONS

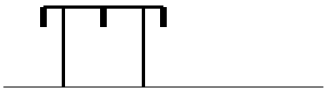
Contents - Reservation & Easement - **132kV Reservation Recommendations**

1) Single Pole Line.
(maximum 20 metre height)
40 metre easement

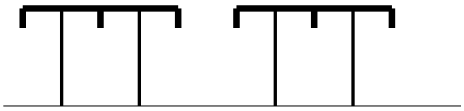


2) Twin Single Pole Lines
(maximum 20 metre height)
20 + 20 + 20 = 60 metre easement

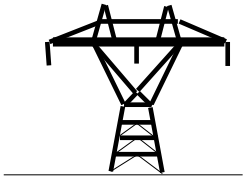
3) Single " H " Pole Line
(maximum 18 metre height)
35 metre easement



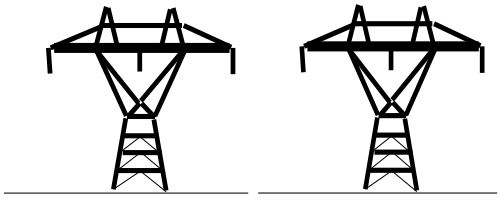
4) Twin " H " Pole Line
(maximum 18 metre height)
17.5 + 20 + 17.5 = 55 metre easement



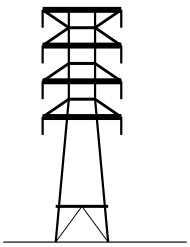
5) Single Circuit Steel Tower Lines
(20 up to 30 metre height)
45 metre easement



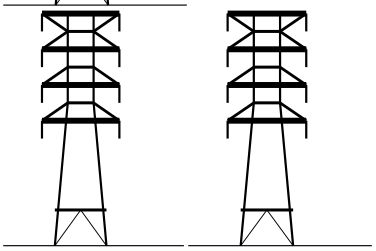
6) Twinned Single Circuit Steel Tower Lines
(20 up to 30 metre height)
22.5 + 30 + 22.5 = 75 metre easement



7) Double Circuit Steel Tower Lines
(supporting one or two circuits, up to 35 metres tower height)
50 to 70 metre easement depending on structure height



8) Twinned Double Circuit Steel Tower Lines
(tower heights 25 to 35 metres)
25 + 30 + 25 = **80** OR 35 + 30 + 35 = **100** metre easement



Notes:

- Reservations 1,2,7 & 8 should achieve a 500 V/m maximum. All reservations meet a 1kV/m limit at the edge.
- Recommended reservations 3 and 4 fall slightly short of meeting the full structural failure requirement, as do reservations 5 and 6 for larger tower heights.
- Above drawings not to scale.
- For vegetation clearances refer to Drawing. A3 3881-006 Minimum Tree clearance to Subtransmission Lines.

Top Of This Section

SUMMARY OF 132KV EASEMENT WIDTHS TO SATISFY VARIOUS CRITERIA

For tree clearance, refer to drawing 3811-006 Minimum Tree Clearance to Subtransmission Lines.

STRUCTURE CONFIGURATION	AUTHORITY (1)	EASEMENT WIDTH	LINE (2)	COMMENTS
Single 132 kV Pole Line	Existing easement (6) EIS & Failure 500 V/m	? 25 to 40 metres 40 metres	Canberra – Gold Creek Bruce – Belconnen Bruce – Gold Creek Gilmore – Causeway	Pole height: 13 – 20 m
Twin 132 kV Pole Lines	Existing easement (6) (4) 500 V/m & Failure EIS	45 = 10 + 25 + 10 m ? = ? + 18 + ? 60 = 20 + 20 + 20 45 to 80 metres	Bruce – Causeway Woden – Wanniassa Causeway – City East Gilmore – Causeway Wanniassa – Gilmore Gilmore – Theodore	Actually 24m
Single 132 kV "H" Pole Lines	500 V/m 1kV/m	50 metres 35 metres	None in 132 kV System	
Twin 132 kV "H" Pole Lines	Existing easement (6) EIS & Failure 500 V/m 1kV/m	45.7 = 11.6 + 22.5 + 11.6m 70 – 90 metres 70 = 25 + 20 + 25m 55 = 17.5 + 20 + 17.5 m	Bruce – City East Bruce – Causeway Causeway – City East	
Single Circuit Steel Tower	Existing easement (6) EIS 500 V/m 1kV/m	30 to 40 metres 40 to 45 metres 60 metres 45 metres	Canberra – Woden Canberra – Latham Canberra – Gold Creek Latham – Belconnen Bruce – Belconnen Bruce – Gold Creek Bruce – Civic Civic – Woden	
Twin 132 kV Single Circuit Towers	Existing easement (6) Actual (4) EIS & Failure 500 V/m 1kV/m	? = 15 + 27.3 + undefined 60 ? = 15 + 30 + 15? 70 to 90 metres 90 metres 75 metres	Canberra – Woden Canberra – Latham Canberra – Gold Creek Civic – Woden	Tower height: 20 – 30 m
Double Circuit Steel Tower	Existing easement (6) 500 V/m Failure	45 to 50 metres 45 to 50 metres 50 to 70 metres	Bruce – Civic Civic – Woden	Dependent on phase arrangement. Tower height: 25 – 35 m
Single Circuit on Double Circuit Tower	500 V/m	50 to 60 metres	None in 132 kV System	
SC & DC on Twinned Double Circuit Towers (3)	Existing easement (6) 500 V/m Failure	60 = 15 + 30 + 15? 75 = 25 (SC) + 30 (DC) + 20m 80 to 100 metres	Bruce – Gold Creek Bruce – City East Bruce – Causeway	Tower height: 25 – 35 m

Notes:

(1) EIS: 1984 132kV Subtransmission Environmental Impact Statement. Range shown is from "situations of extreme constraint" to "an ideal situation"
500V/m:} Estimated easement widths so that these electric field limits are not exceeded at the edge of the easement.
1kV/m: }
Failure: (Estimated) widths to permit worse case structural failure of support structure(s) to remain within the easement. Varies with structure height.

(2) Refer to drawing numbers 1812-001, 1812-002, and 1812-003. Note that not all sections of the 132kV system are included in this list. Minor sections are excluded.

(3) SC denotes Single Circuit, DC denotes Double Circuit – the single circuit is on one of the two towers, the double circuit on the other.
(4) Easement width varies along the line.
(5) ? =To be determined Later / Unknown / Depends on the situation in the field.
(6) For more details on the existing easements widths please refer to electronic 132 kV asset records.

Top Of This Section

11 KV & 415V RESERVATION RECOMMENDATIONS

Contents - Reservation & Easement - **11kV and 415V Overhead Reservation Recommendations**

Drawing Numbers:

- A2 393-002 STANDARD ALIGNMENTS AND RESERVATIONS OF OVERHEAD MAINS
- A3 3811-012 MINIMUM TREE CLEARANCE TO LV, HV, AND SERVICE LINES
- A2 3881-004 MINIMUM CLEARANCES LOW VOLTAGE OVERHEAD CONDUCTOR

Notes:
Reference: - Manual Overhead - Mains Standards Drawings - Section 6. Information Drawings

Top Of This Section

STANDARD RESERVATION WIDTH FOR COMMON OVERHEAD CONSTRUCTIONS

Contents - Reservation & Easement - **Standard Reservation Width for Overhead Constructions**

Intended land use near power lines reservation boundaries shall be discussed with ActewAGL on a case-by-case basis. This is to ensure that safety to the public and security of the network are not compromised by inappropriate land use. The table below sets out reservation width of the overhead lines.

VOLTAGE	DESCRIPTION	RESERVATION WIDTH (m)
415	Overhead adjacent to rear property lines	5
415	Overhead adjacent to side property lines	5
415	Overhead in verges and laneways	5
415V, 11kV	Combined overhead at any location	10
11kV	Overhead at any location	10
66kV	Single wood pole	30
66kV	Twin wood pole	45
132kV	Single pole (concrete & wood)	40 (1)
132kV	Twin pole (concrete & wood)	60 (1)
132kV	Single Wood H-pole	35 (1)
132kV	Twin Wood H- pole	55 (1)
132kV	Single Circuit Steel Lattice Tower	45 (1)
132kV	Twin Circuit Steel Lattice Tower	75 (1)
132kV	Double Circuit Steel lattice Tower	70 (1,2)
132kV	Twin Double Circuit Steel Lattice Tower	100 (1,3)

Notes:

(1) The widths of the 132kV easements have been determined to include considerations into electrical safety, structural failure and electromagnetic fields as set out in the Australian NH & MRC guidelines.

(2) This the maximum width for the construction configuration, however this may be varied between 50 and 70 metres depending on the height of the structure (between 25 and 35 metres) - refer to the list of permitted and not permitted public uses and activities within the subtransmission easement.

(3) This is the maximum width for the construction configuration, however this may be varied between 80 and 100 metres depending on the height of the structure (between 25 and 35 metres) - refer the list of permitted and not permitted public uses and activities within the subtransmission easement.

Top Of This Section

POWER LINES AND LAND USE

Contents - Reservation & Easement - **Power Lines and Land Use**

PERMITTED LAND USES	NON-PERMITTED LAND USES
Grazing, agriculture, market gardening, nurseries	Permanent or temporary habitation (tents, caravans)
Cemeteries, both pet and human.	
Landscaping, trees and shrubs of limited height	Structures other than fences, poles of lighting standards of limited height
Car parking for conventional vehicles	Swimming pools
Water storage, pollution control ponds, drainage channels and floodways (swimming not permitted, and boat mast height limited)	Storage of materials
	Saleyards or parking for large vehicles
Roads, cycleways, footpaths	
Golf courses, providing that fairways are sited so as to avoid insulator damage by golf balls	Refuelling of vehicles
Neighbourhood playing fields, restricted to ground level	Large spray irrigators of the gun type
sports and activities, with limitations on the location of goal	Children's playgrounds
posts, floodlights, high fencing, tennis umpires' chairs and the like.	Aerial activities (flying, hang gliding, kites, model planes)

Notes:

(1) Ref. File G92/137

Top Of This Section

UNDERGROUND CABLES: RESERVATION AND ALIGNMENTS IN VERGES, MEDIANS AND PUBLIC OPEN SPACES

Contents - Reservation & Easement - **Underground Cables - Reservation and alignments**
- Underground cable reservation
- Mains and streetlight cable alignments and reservation in verges
- Mains and streetlight cable alignments and reservations in laneways

VOLTAGE	DESCRIPTION	RESERVATION WIDTH
415V	Underground	2.5 m
11 kV	Underground single cable	3.0 m
11 kV	Underground multiple cables	1.5 m from the outermost cable
132 kV	Underground cables	3.0 m from the outermost cable

THE RESERVATION WIDTH IS DETERMINED BY THE NEED OF VEHICLE ACCESS.

MAINS AND STREETLIGHT CABLE ALIGNMENTS AND RESERVATIONS IN VERGES

Details of cable reservations and alignments in verges and laneways are shown on Drawing No: A2 393-001 STANDARD ALIGNMENTS-UNDERGROUND MAINS AND STREETLIGHT CABLING. The details are given the two tables.

VERGE WIDTH	CABLE ALIGNMENTS	RESERVATION WIDTH (m)	RESERVATION LIMITS (m)
Less than 4.5 metres	all cable: 0.9 metres from property line	0.5	between 0.6 and 1.1 from property line
4.5metres to less than 6.0 metres	all cable: 2.4 metres from property line	0.7	between 2.1 and 2.8 from property line
6.0 metres and wider	mains cable: 2.4 metres from property line S.L. cable: 2.0 metres from kerb line	0.7 0.6	between 2.1 and 2.8 from property line between 1.6 and 2.2 from kerb line

Top Of This Section

MAINS AND STREETLIGHT CABLE ALIGNMENTS AND RESERVATIONS IN LANEWAYS

Contents - Reservation & Easement - Underground Cables - Reservation and alignments
- Mains and streetlight cable alignments and reservation in verges
- **Mains and streetlight cable alignments and reservations in laneways**

Details of cable reservations and alignments in verges and laneways are shown on Drawing No:
A2 393-001 STANDARD ALIGNMENTS-UNDERGROUND MAINS AND STREETLIGHT CABLING.
The details are given the two tables.

LANEWAY WIDTH	CABLE ALIGNMENT MEASURED FROM SERVICE LINE (m)	RESERVATION WIDTH (m)	CABLE RESERVATION LIMITS MEASURED FROM SERVICE LINE (m)
less than 6.0 metres	2.5	0.9	between 2.1 and 3.0
6.0 metres and wider	4.5	1.2	between 4.0 and 5.2

Notes:
1. In new developments the "service line" in laneways shall be the property line on the left hand side when viewed from the northern most end. Where laneways are directly east-west the "service line" shall be on the southern property line.
2. Above table is are part of reference 8. Branch Instruction No. 17. Mains - Underground Cable Alignments, Reservations and Related Matters. Read in conjunction with Drawings: 393-001 " Standard Alignments - Underground Mains and Streetlight Cabling". 390-002 " Reinstatement and Trench Details"

Top Of This Section

Land Use near Zone Substations and Switching Stations

Intended land use near zone substation and switching stations shall be discussed with ActewAGL on a case-by-case basis. This is to ensure that safety to the public and security of the network are not compromised by inappropriate land use. The table below provides examples of land use restrictions.

Distance	Examples
Within 10 metres from the fence or building.	Permitted • Trees under 2 metres Not Permitted • Tress above 2 metres • Any other permanent or temporary structures
Beyond 10 metres and within 100 metres from the fence or building	Permitted • Trees of height less than their distance to the fence • Car park, water storage, drainage channels, floodway • Roads, cycle ways and footpaths • Parks, playfields and recreational facilities • Certain type of structures with height less than their distance to the fence Not Permitted • Metal fences, rails and metallic wires installations that connect to remote locations • Structures that may fall onto the substation buildings or fences, or cause interference with substation operations • Activities that may resulting flying objects landing, hitting or damaging equipment inside the fence

CALCULATIONS

This section contains some equations, numerical data, and methods used to calculate some of the values in this manual.

CALCULATIONS - MATERIAL PROPERTIES

Contents - Calculations – **Material Properties**

Material Properties Used:

Material	Temperature Coefficient Of Resistance (@20°C) (α)	Resistivity (@20°C) ($\mu\Omega$.m) (ρ)	Australian Standard
Copper	0.00381	0.01777	AS 1746 - 1991
Aluminium (1350)	0.00403	0.0283	AS 1531 - 1991
ASCR	0.00403		AS 3607 - 1989
Steel (SC/GZ)	0.0044	0.17	AS 1222.1 - 1992

See Metal Manufactures Ltd. Publication 5/81-October 1981, "Kembla®, Conductors for Overhead Transmission and Distribution.", page 5

Top Of This Section

CALCULATIONS - CONDUCTOR PROPERTIES

Contents - Calculations – **Conductor Properties**

Below are properties of the conductors that are used in the calculations in this manual.
Stranding Constant
Given in Metal Manufactures Ltd. Publication 5/81-October 1981, "Kembla®, Conductors for Overhead Transmission and Distribution.", Table 6
Resistivity Constant
Given in Metal Manufactures Ltd. Publication 5/81-October 1981, "Kembla®, Conductors for Overhead Transmission and Distribution.", Table 6
K_s – Skin effect ratio – assumed to be 1.015 for all conductors.
K_m – Magnetic Effect Ratio – typically between 1.0 and 1.1. Given by ESAA Publication D(b)5-1988 - "Current Rating of Bare Overhead Line Conductors"., page 11

GMR
Geometric Mean Radius, a function of the dimensions and magnetic properties of the conductor. It is calculated by using the following table:
Let d_s = diameter of 1 strand.

Total Number Of Strands	Nominal Diameter	GMR
3	$(1+ 2/\sqrt{3})d_s$	$0.6779r_c$
7	$3d_s$	$0.7255r_c$
19	$5d_s$	$0.7576r_c$
37	$7d_s$	$0.7681r_c$
61	$9d_s$	$0.7720r_c$

Where r_c = nominal radius = radius of the conductor = nominal diameter / 2.

These coefficients of GMR came from "Electrical Characteristics of Overhead Lines", by S. Butterworth, ERA: Technical Report O/T4, 1954; page 25.

Note that these values do not take into account type of material used in the conductor. This means that there can not be any factor taken into account if the conductor has, say, a steel core.

AS 3851 – 1991 also has a formula for the GMR (given in appendix B).
It is the same, but with different coefficients for the GMR:

Total Number Of Strands	GMR as given by AS 3851 - 1991
3	$0.8411r_c$
7	$0.8255r_c$
19	$0.8723r_c$
37	$0.8800r_c$
61	$0.8878r_c$

NOTE: these values were **NOT** used in the calculation of this manual. It was decided that it is better to keep the values consistent with the values as calculated previously, calculated with the formula from Butterworth.

The impedance and voltage drop values using the 3 formulae for the GMR (Butterworth, Kembla®, Standards) were compared to each other. The worst case between the Kembla® and Butterworth values was a 7.6% rise from the Butterworth, for the Raisin low voltage positive sequence reactance. The worst case between the Standards and Butterworth values was a –3.5% drop from the Butterworth, for the Steel low voltage positive sequence reactance. Conductor specifications are in accordance with Metal Manufactures Ltd. Publication 5/81-October 1981, "Kembla®, Conductors for Overhead Transmission and Distribution."

Top Of This Section

CALCULATIONS - RESISTANCE TEMPERATURE CONVERSION

If the (positive sequence) resistance (R1) is known for a particular temperature, then the resistance at different temperature can be calculated, by using:

$R2 = R1 (1 + \alpha_1(t_2-t_1))$

Where:
R2 = New resistance value at x°C,
R1 = Resistance value at 20°C
α_1 = Temperature coefficient of resistance at 20°C (given in Material Properties)
t_2 = New temperature in °C
t_1 = 20°C

If the resistance is known at a particular temperature that is not 20°C, then the resistance at 20°C can be calculated by using:
$R1 = R2 / (1 + \alpha_1(t_2-t_1))$

Note that this method can also be used for zero sequence resistance.

Top Of This Section

CALCULATIONS - OVERHEAD – COPPER EQUIVALENCE

Contents - Calculations - **Overhead – Copper Equivalence**

For Copper conductors the equivalent copper area is just the area of the conductor:
Area (mm^2) = πr^2 x Number of Strands

For AAC conductors, the equivalent copper area is:
Area (mm^2) = $\pi r^2 * sc * \rho_{Cu} / \rho_{Al}$

For ACSR conductors, except for Raisin, the steel core is neglected (following the guidelines of Metal Manufactures Ltd. Publication 5/81-October 1981, "Kembla®, Conductors for Overhead Transmission and Distribution."), and the copper equivalent area is:
Area (mm^2) = $\pi r^2 * sc * \rho_{Cu} / \rho_{Al}$

For Raisin, the steel core is included in the calculation (following the guidelines of Metal Manufactures Ltd. Publication 5/81-October 1981, "Kembla®, Conductors for Overhead Transmission and Distribution."), and so the copper equivalent area is:
Area (mm^2) = (Cu equiv of Al Area) + (Cu equiv of Steel area)
= $(\pi r^2 * sc * \rho_{Cu} / \rho_{Al}) + (\pi r^2 * sc * \rho_{Cu} / \rho_{Steel})$

Where:
r = the radius of one strand of the conductor in mm.
Note that values in inches are multiplied by 25.4 to obtain a value in mm.
sc = Stranding Constant, as listed in Table 6, Metal Manufactures Ltd. Publication 5/81 - 1981, Kembla®, Conductors for Overhead Transmission and Distribution".
ρ_{Cu} = Resistivity of Copper, as given in Material Properties
ρ_{Al} = Resistivity of Aluminium, as given in Material Properties
ρ_{Steel} = Resistivity of Steel, as given in Material Properties

See also File Ref: G91/716 "THERMAL AND ELECTRICAL PROPERTIES OF OVERHEAD CONDUCTORS."

Top Of This Section

CALCULATIONS - OVERHEAD – CURRENT RATINGS

Current ratings are calculated in accordance with ESAA Publication D(b)5-1988 - "Current Rating of Bare Overhead Line Conductors".

The current rating (in Amps) is given by the equations below, based on page 7 of ESAA:

$$I = \sqrt{\frac{PR + PF - PS}{R_{ac}}}$$ - For wind conditions

$$I = \sqrt{\frac{PR + PN - PS}{R_{ac}}}$$ - For still air conditions

Where:

R_{ac} = AC Resistance (given in Overhead – AC Resistance)

PR = Power Loss by Radiation (Watts / metre)

= $\pi D \sigma . e[(t_c + 273)^4 - \frac{1}{2}(t_g + 273)^4 - \frac{1}{2}(t_d + 273)^4]$

PF = Power Loss by Forced Convection (Watts / metre)

= $\pi \lambda_f (t_c - t_a) B(\mathrm{Re})^n$ **See Note below

PN = Power Loss by Natural Convection (Watts / metre)

= $\pi \lambda_f (t_c - t_a) Nu$

PS = Power Gain by Solar Heat Input (Watts / metre)

= $aD[I_{dir}(1 + \frac{\pi}{2}F) + I_{diff}\frac{\pi}{2}(1 + F)]$

Where:

t_c = Conductor temperature (°C)

t_a = Ambient temperature (°C)

t_d = Sky temperature (°C)

= 0.0552 $(t_a + 273)^{1.5}$ – 273

t_g = Ground temperature (°C)

= t_a + 5 for daytime conditions

= t_a - 5 for night time conditions

λ_f = Thermal Conductivity of the Air Film (W/mK)

= 2.42 x 10^{-2} + 7.2 x 10^{-5} $(t_c + t_a)$ / 2

ν_f = Viscosity of the Air Film (m^2 / s)

= 1.32 x 10^{-5} + 9.5 x 10^{-8} $(t_c + t_a)$ / 2

D = Diameter of the conductor (m)

g = Acceleration due to gravity, 9.81 m/s^2

Gr = Grashof Number

$$= \frac{D^3 g(t_c - t_a)}{\upsilon_f{}^2 [273 + (t_c + t_a)/2]}$$

Pr = Prandtl Number

= 0.715 – 2.5 x 10^{-4} $(t_c + t_a)$ / 2

(A, m) = If (Gr.Pr <= 10^4), then (A, m) = (0.850, 0.188), otherwise, (A, m) = (0.480, 0.250)

Nu = Nusselt Number

= A $(Gr.Pr)^m$

= Stefan-Boltzmann constant = 5.67 x 10^{-8} ($W/m^2 K^4$)

e = Emissivity of the conductor

a = Solar absorption coefficient

v = Wind Velocity (m/s)

Re = Reynolds number

= vD / ν_f

(B, n) = If (Re <= 2650), then (B, n) = (0.641, 0.471), otherwise, (B, n) = (0.048, 0.800)

I_{dir} = Direct solar radiation intensity (W/m^2)

I_{diff} = Diffuse solar radiation intensity (W/m^2)

= 100 W/m^2 for daytime, 0 W/m^2 for night time

F = Albedo (ground reflectance)
= 0.2

Note on PF – Power Loss by Forced Convection
The wind direction is assumed to be in a traverse direction to the conductor (see section 4.4 of ESAA). This results in the $[0.42 + C(\sin\psi)^P]$ term of the PF (Power loss by forced convection) equation equalling 1, and thus is not included in this equation.

If there is not enough wind blowing, then it is possible that the current rating is unable to be calculated using the equations given in the ESAA publication. This is because it is not possible to take the square root of a negative number. This is marked as “NA” in the rating tables.

Conductor specifications are in accordance with Metal Manufactures Ltd. Publication 5/81-October 1981, "Kembla®, Conductors for Overhead Transmission and Distribution.”

See also File Ref: G91/716 "THERMAL AND ELECTRICAL PROPERTIES OF OVERHEAD CONDUCTORS."

Top Of This Section

CALCULATIONS - OVERHEAD – DC RESISTANCE

Contents - Calculations - **Overhead – DC Resistance**

The DC Resistance @ 20°C is calculated for each conductor (represented by R_{DC}) by:

R_{DC} = resistance stranding constant * ρ * L / A

Where:
Resistance stranding constant: given in Conductor Properties
ρ = resistivity of the conductor material at 20°C: given in Material Properties.
L = length of the conductor
A = cross-sectional area of 1 strand.

Note that for ACSR conductors, the steel core is usually ignored, except in the case of Raisin: where the resistivities are added up in parallel, as per Metal Manufactures Ltd. Publication 5/81-October 1981, "Kembla®, Conductors for Overhead Transmission and Distribution.", page 10.

Top Of This Section

CALCULATIONS - OVERHEAD – AC RESISTANCE

Contents - Calculations - **Overhead – AC Resistance**

The AC Resistance is denoted by R1, and is calculated by:

$R1 = R_{DC} (1 + \alpha(t - 20)) K_m K_s$

Where:
R_{DC} = DC Resistance at 20°C: given in Overhead – DC Resistance
α = Temperature coefficient of resistance at 20°C: (given in Material Properties).
t = temperature in °C.
K_m = Magnetic effect ratio: given in Conductor Properties
K_s = Skin effect ratio: given in Conductor Properties

$(1 + \alpha(t - 20))$ scales the resistance to the correct temperature, while:
$K_m K_s$ is the conversion factor to go from DC to AC resistance.

(see file: G91/716 "THERMAL AND ELECTRICAL PROPERTIES OF OVERHEAD CONDUCTORS.")

CALCULATIONS - OVERHEAD – POSITIVE SEQUENCE REACTANCE

Contents - Calculations - **Overhead – Positive Sequence Reactance**

The Positive Sequence Reactance is donated by X1, and is then found by using:

$X1 = 0.1446 \log_{10} (GMD/GMR)$

Where:
GMD = Geometric Mean Distance, a property of the configuration of the conductors.
Typically, for HV – GMD = 1.28 m, while for LV – GMD = 0.96 m.

GMR = a property of the conductor, given in Conductor Properties

(see file: G91/716 "THERMAL AND ELECTRICAL PROPERTIES OF OVERHEAD CONDUCTORS.")

CALCULATIONS - OVERHEAD – HV – ZERO SEQUENCE RESISTANCE

Contents - Calculations - **Overhead – HV – Zero Sequence Resistance**

Zero sequence resistance is denoted by R0.

It is given by:
R0 = R1 + 0.003*f

Where:
f is the frequency (50 Hz in ActewAGL network).
R1 = Positive Sequence (AC) Resistance – given in Overhead – AC Resistance

(see file: G91/716 "THERMAL AND ELECTRICAL PROPERTIES OF OVERHEAD CONDUCTORS.")

CALCULATIONS - OVERHEAD – HV – ZERO SEQUENCE REACTANCE

Contents - Calculations - **Overhead – HV – Zero Sequence Reactance**

Zero Sequence Reactance is denoted by X0. It is given by:

$$X0 = 0.0087\, f\, \log_{10}\left(\frac{De}{\sqrt[3]{GMR \times GMD^2}}\right)$$

Where:
f = frequency = 50 Hz
De = Depth of Fictitious Return Conductor = 660√(ρ/f) = 660√(250/50) [metres]
GMR = Geometric Mean Radius: given in Conductor Properties
GMD = Geometric Mean Distance, a property of the configuration of the conductors.
Typically, for 11kV – GMD = 1.28 m, while for LV – GMD = 0.96 m.

(see file: G91/716 "THERMAL AND ELECTRICAL PROPERTIES OF OVERHEAD CONDUCTORS.")

It is assumed that no overhead earth wire is used.
HV covers 11 kV only.

Top Of This Section

CALCULATIONS - OVERHEAD – LV – ZERO SEQUENCE IMPEDANCE

Contents - Calculations - **Overhead – LV – Zero Sequence Impedance**

The Low Voltage zero sequence resistance and reactance are just the real and imaginary components of the impedance (Z0) that is calculated below.

$Z0 = Z0(a) - (Z0(ag)^2)/Z0(g)$

Where:

Z0(g) = Zero sequence self impedance of 1 ground wire

$$= 3R1 + 0.003f + j0.0087f \log_{10}\left(\frac{De}{GMR}\right)$$

Z0(a) = Zero sequence self impedance of the three phase circuit

$$= R1 + 0.003f + j0.0087f \log_{10}\left(\frac{De}{\sqrt[3]{GMR(GMD)^2}}\right)$$

Z0(ag) = Zero sequence mutual impedance between the three phase circuit as one group of conductors and the ground wire as the other group.

$$= 0.003f + j0.0087f \log_{10}\left(\frac{De}{\sqrt[3]{dAn.dBn.dCn}}\right)$$

Where:

R1 = Positive Sequence Resistance, given in: Overhead – AC Resistance

f = frequency = 50 Hz

De = Depth of Fictitious Return Conductor = $660\sqrt{\rho / f}$ = $660\sqrt{250/50}$ [metres]

GMR = Geometric Mean Radius: given in Conductor Properties

GMD = Geometric Mean Distance, a property of the configuration of the conductors.
Typically, for HV – GMD = 1.28 m, while for LV – GMD = 0.96 m.

dAn, dBn, dCn: are the distance between the respective phases and neutral.

(see file: G91/716 "THERMAL AND ELECTRICAL PROPERTIES OF OVERHEAD CONDUCTORS.")

Top Of This Section

CALCULATIONS - VOLTAGE DROP

Contents - Calculations - **Voltage Drop**

Voltage drops at particular temperatures for particular power factors were determined using the positive sequence impedance values in the formula:

Voltage Drop = R1cos (θ) + X1sin (θ)

θ = power factor angle; as shown in AS3008.1.

pf = power factor (eg: 0.8, 0.9, 0.95)

In this case, cos(θ) = pf

So: sin(θ) = sin($\cos^{-1}$(power factor))
So: Voltage Drop = R1*pf + X1*sin($\cos^{-1}$(pf)).

Note that if the conductor is 1 phase, 1 neutral, then to account for the voltage drop on the neutral the value must be multiplied by 2 to get a phase to neutral volt drop. To get volt drop based on phase to phase voltage (for example for 3 phase & 1 neutral conductor), the voltage drop must be multiplied by $\sqrt{3}$.

For Overhead Positive Sequence Resistance, refer to Overhead – AC Resistance
For Overhead Positive Sequence Reactance, refer to Overhead – Positive Sequence Reactance

Top Of This Section

REGISTRY OF CHANGES

Changes made since the release in February 2001 are tabled below:

Revised by	Date Of Change	Revision Number	Section / Topic	Description Of Change
Kevin Paice	12/2/2001	Initial		Release of first online, updated version of the manual
Janusz Worony	20/7/2001	Initial		General corrections and editing
Yili Zhu	21/06/2005	1	Front page	• General corrections and editing
			UG HV Cable Ratings	• Minor changes to front page Cable rating table updated
			Underground cables: reservation	• Cable reservation width added
			Land use near zone substations	• Land use restrictions near zone substations added
Yili Zhu	21/11/2005	2	HV Feeder Rating	New Section for HV Feeder Ratings
Yili Zhu	30/10/2006	3	Fyshwick Zone Substation ratings	TX 1 data updated
Y Zhu R Morriss	13/03/2007	4	Fyshwick Zone Substation data	Rating, text and diagrams updated
			Distribution Substation	A new section for distribution substation electrical parameters added
Tim Anderson	31/3/2008	5	Fyshwick Zone Substation Data	Data updated for new TX 2 installed at Fyshwick Zone
B Bramanathan	11/02/2010	6	Telopea Park Zone Substation data	Rating and text updated
Tim Anderson	19/1/2012	7	Various tables	Reformatted tables to show header row at the top of each page
			HV feeder ratings	Changed firm factor from 0.67 to 0.75
Nicholas Lee	11/02/2013	8	HV feeder ratings	Added H.V Feeder rating for ANU No5, Nicholson, Joy Cummins, Lampard, Pialligo, CNBP1 and Russell No3 based on Aecom's Review of ActewAGL Electrical Data.
			Overhead Conductor	Added metric equivalent conductor for 3/12 Steel conductor.
Nicholas Lee	18/06/2013	9	HV feeder ratings	Added H.V Feeder rating for HLPS, Easty, Garran, Aero Park, CNBP2 and Tralee Feeder. Amended Harman Feeder Rating. Modified KF1 Feeder's firm rating factor. Removed KF2 Feeder because KF2 is now terminated into SUB9191 as part of power house feeder. Amended all HV feeder firm rating. Previous firm rating is based on rounding to the nearest 5.
			Transmission Cable Rating	Added Section on 132kV Transmission Cable Rating
			OPGW	Added Section on OPGW for Gilmore-Williamsdale and Theodore-Williamsdale
Firoz Gotla	23/7/2013	10	Zone Substations	Transformer Ratings revised Added Angle Crossing Zone Substation Revised new transformer capacity for Civic and Fyshwick Zone Substation

Top Of This Section

Contents

REFERENCES

Contents

1. Thermal and Electrical Properties of Overhead Conductors
Anant Singh
File Ref: G91/716 (DM#532135)

2. Thermal Cyclic Ratings of 11kV Cables. Original paper by M.K. Johnson, updated by T.Falkland (1979) and R. Forster(1989)
File Ref: G89/568. (DM#532136)

3. MM Cables Product Specification and Technical Data.
Sections 2, 4.1.2 and 4.1.4

4. AS/NZS 3008.1.1:2009 : Electrical installations - Selection of cables - Cables for alternating voltages up to and including 0.6/1 kV - Typical Australian installation conditions

5. AS/NZS 4026:2008 : Electric cables - For underground residential distribution systems

6. Overhead Lines - Reservations, Easements and Alignments.
393-002 " Standard Alignments and Reservations - Overhead Lines "

7. 393-001 " Preferred Standard Alignments - Underground Mains and Streetlight Cabling".
390-002 " Conduit Installation – Roadways and Driveways"

8. Manual Overhead - Mains Standards Drawings - Section 6 Information Drawings

9. 2-Hour Emergency Rating of Zone Substation Transformers
Anant Singh
File Ref: G72/31

10. AS 2374.7-1997 : Power transformers - Loading guide for oil-immersed power transformers

11. ESAA Publication D(b)5-1988
Current Rating of Bare Overhead Line Conductors

12. Metal Manufactures Ltd. Publication 5/81 - October 1981, Kembla®, Conductors for Overhead Transmission and Distribution

13. ACTEW Tender 422/93, Olex Cables - Option B

14. AS/NZS 3560.2:2003 : Electric cables - Cross-linked polyethylene insulated - Aerial bundled - For working voltages up to and including 0.6/1(1.2) kV - Copper conductors

15. AS 1746-1991 : Conductors - Bare overhead - Hard-drawn copper

16. AS 1531-1991 : Conductors - Bare overhead -- Aluminium and aluminium alloy

17. AS 3607-1989 : Conductors - Bare overhead, aluminium and aluminium alloy - Steel reinforced
18. AS 1222.1-1992 : Steel conductors and stays - Bare overhead - Galvanized (SC/GZ)

19. AS 1222.2-1992 : Steel conductors and stays - Bare overhead - Aluminium clad (SC/AC)

20. OLEX Cables – “Aluminium Conductors, High Fault Level, 6.35/11 kV Three Core Cu Wire Individually Screened, PVC Sheathed”, XLPE Cables.

Top Of This Section

Contents