Short Circuit Calculations Quick Three Phase

Short circuit current levels must be known before fuses or other equipment can be correctly applied. For fuses, unlike circuit breakers, there are four levels of interest. These are 10,000, 50,000, 100,000 and 200,000 RMS symmetrical amperes.

Rigorous determination of short circuit currents requires accurate reactance and resistance data for each power component from the utility generating station down to the point of the fault. It is time-consuming for a plant engineer to collect all this information and yet he is the one most affected by short circuit hazards.

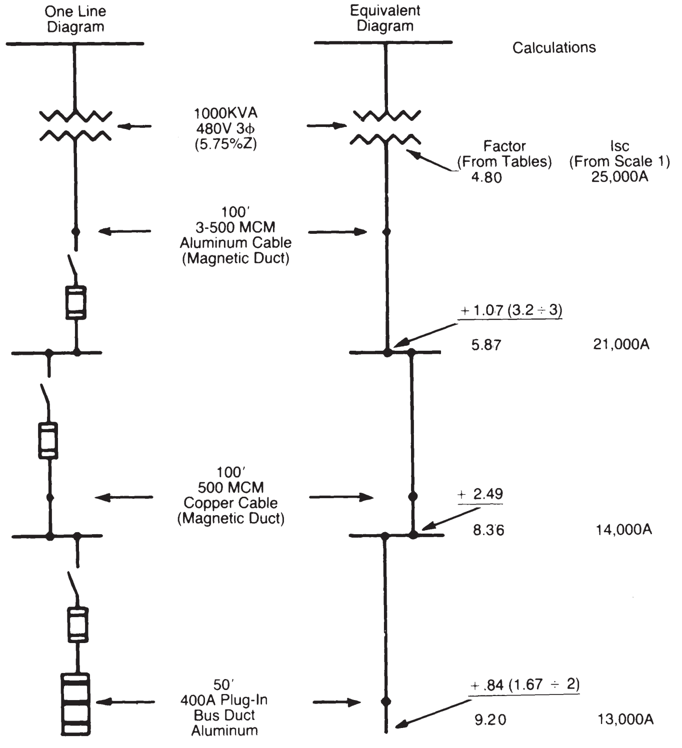
There have been several approaches to “easy” short circuit calculations which have been cumbersome to be of practical use. The method described here is not new but it is the simplest of all approaches.

Example 1:
What is the potential short circuit current at various points in a 480V, 3-phase system fed by a 1000kVA, 5.75%Z transformer? (Assume primary short circuit power to be 500MVA.)

In summary, each basic component of the industrial electrical distribution system is pre-assigned a single factor based on the impedance it adds to the system. For instance, a 1000kVA, 480 volt, 5.75%Z transformer has a factor of 4.80 obtained from Table A. This factor corresponds with 25,000 RMS short circuit amperes (directly read on Scale 1, pg 55). Note: Factors change proportionally with transformer impedance. If this transformer were 5.00%Z, the factor would be 5.00/5.75 x 4.80 = 4.17.

Cable and bus factors are based on 100 foot lengths. Shorter or longer lengths have proportionately smaller or larger factors (i.e. 50’ length = 1/2 factor; 200’ length = 2 x factor). Basic component factors are listed on following pages in tables A through D.

To find the short circuit current at any point in the system, simply add the factors as they appear in the system from service entrance to fault point and read the available current on Scale 1.



Example 2:
If the primary short circuit power were 50MVA (instead of 500MVA) in this same system, what would Isc be at the transformer? At the end of the bus duct run?

Answer:
From the Primary MVA correction factor table A1, the factor for 50MVA (at 480V) is 1.74. The new factor at the transformer is then 4.80 + 1.74 = 6.54 and Isc is reduced to 18,000A (Scale 1). The new factor at the bus duct is 9.21 + 1.74 = 10.95 Isc = 11,000A (Scale 1).

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Short Circuit Calculations Quick Three Phase

Component factor tables- transformers

The transformer factors are based on available primary short circuit power of 500MVA and listed in Table A. For systems with other than 500MVA primary short circuit power, add the appropriate correction factors from Table A1 to the transformer factor found in Table A.

A- Three Phase Transformer Factors

Transformer		Factor 3 Phase Voltage			
kVA	%Z	208	240	480	600
75	1.60	9.00	10.00	20.00	24.00
100	1.70	7.00	8.00	16.00	20.00
112.5	2.00	7.40	8.50	17.00	21.00
150	2.00	5.40	6.00	12.00	15.00
225	2.00	3.70	4.00	8.00	10.00
300	2.00	2.70	3.00	6.00	7.50
500	2.50	2.15	2.25	4.50	5.60
750	5.75	2.78	3.25	6.50	8.00
1000	5.75	2.24	2.40	4.80	6.00
1500	5.75	1.48	1.60	3.20	4.00
2000	5.75	NA	1.20	2.40	3.00
2500	5.75	NA	.95	1.91	2.40

Notes: 208 volt 3φ transformer factors are calculated for 50% motor load. 240, 480 and 600 volt 3φ transformer factors are calculated for 100% motor load. A phase-to-phase fault is .866 times the calculated 3-phase value.

A1- Transformer Correction Factors

Primary MVA	Factor 3 Phase Voltage			
	208	240	480	600
15	2.82	3.24	6.43	8.05
25	1.65	1.90	3.78	4.73
50	.78	.90	1.74	2.24
100	.34	.40	.80	1.00
150	.20	.23	.46	.58
250	.08	.10	.20	.25
Infinite	-.08	-.10	-.20	-.25

A2- Factor for Second Three Phase Transformer in System

1. Determine system factor at the second transformer primary.

Example:

Isc @ 480V = 40,000A. Factor is 3.00 (from Scale 1).

2. Adjust factor in proportion to voltage ratio of second transformer.

Example:

For 208V, factor changes to (208 ÷ 480) x 3.00 = 1.30

3. Add factor for second 3φ transformer.

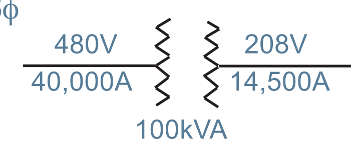
Example:

Factor for 100kVA, 208V, 1.70%Z transformer is 7.00.

Total Factor = 7.00 + 1.30 = 8.30

(Isc = 14,500A)

3φ to 3φ



Short Circuit Calculations Quick Three Phase

A3- Factors for Single Phase Transformer in Three Phase System

Transformer connections must be known before factor can be determined. See Figures A and B (bottom right).

1. Determine system factor at 1ϕ transformer primary, with 480V pri., 120/240V sec. (Figure A)

Example:

Isc @480V = 40,000A, 3ϕ. Factor is 3.00 (from Scale 1).

$$1\phi \text{ factor} = \frac{3\phi \text{ factor}}{.866} = \frac{3.00}{.866} = 3.46$$

2. Adjust factor in proportion to voltage ratio of 480/240V transformer.

Example:

For 240V, 1ϕ factor is (240 ÷ 480) 3.46 = 1.73

3. Add factor for 1ϕ transformer with Figure A connection.

Example:

Factor for 100kVA, 120/240V, 3%Z transformer is:

a. 120V--total factor = 6.22 + 1.73 = 7.95
(Isc = 15,000A)

b. 240V--total factor = 8.64 + 1.73 = 10.37
(Isc = 11,600A)

A3- Single Phase Transformer Factors

Transformer		Factor 1 Phase Voltage		
		120V	240V	120V
kVA	%Z	FIG. A	FIG. A	FIG. B
15	2.5	34.6	48.0	24.0
25	2.5	20.7	28.8	14.4
37.5	2.8	16.6	23.0	11.5
50	3.0	12.5	17.3	8.65
75	3.0	8.28	11.5	5.75
100	3.0	6.22	8.64	4.32
150	2.5	3.46	4.80	2.40
167	2.5	3.10	4.31	2.16
225	2.5	2.30	3.20	1.60
300	3.0	2.07	2.88	1.44
500	4.5	1.86	2.59	1.30

Note: Factor varies with %Z.
Example: 50kVA, 240V secondary with a 1.5%Z has a factor of (1.5%Z ÷ 3.0%Z) x 17.3 = 8.65

3ϕ to 1ϕ

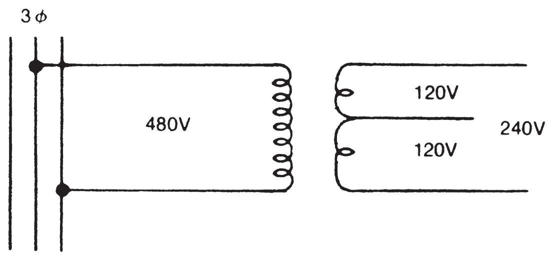


Fig. A

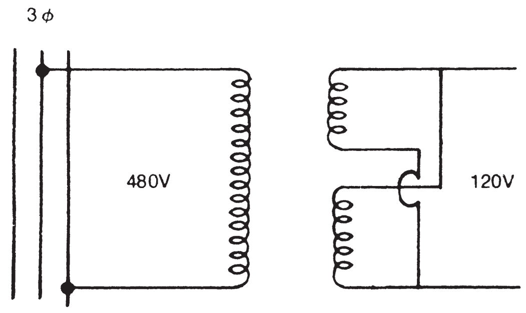


Fig. B

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Short Circuit Calculations Quick Three Phase

Component Factor Tables - Cables in Duct

B/B1- Copper Cables in Duct (Per 100′)

Cable Size	B–Magnetic Duct 3 Phase Voltage				B1–Non-Magnetic Duct 3 Phase Voltage			
	208	240	480	600	208	240	480	600
#8	79.00	68.00	34.00	27.00	78.00	67.60	33.80	27.10
6	50.00	43.00	22.00	17.50	47.90	41.50	20.70	16.60
4	32.00	28.00	14.00	11.15	30.70	26.70	13.30	10.70
2	21.00	18.00	9.00	7.23	19.90	17.20	8.61	6.89
1	17.50	15.00	7.40	5.91	16.20	14.00	7.07	5.60
1/0	14.00	12.20	6.10	4.85	13.20	11.40	5.70	4.57
2/0	11.80	10.20	5.10	4.05	10.60	9.21	4.60	3.68
3/0	9.80	8.50	4.27	3.43	8.87	7.59	3.85	3.08
4/0	8.40	7.30	3.67	2.94	7.57	6.55	3.28	2.62
250kcmil	7.70	6.70	3.37	2.70	6.86	5.95	2.97	2.38
300	7.00	6.10	3.04	2.44	5.75	4.98	2.49	1.98
350	6.60	5.70	2.85	2.28	5.36	4.64	2.32	1.86
400	6.20	5.40	2.70	2.16	5.09	4.41	2.20	1.75
500	5.80	5.00	2.49	2.00	4.66	4.04	2.02	1.62
600	5.50	4.80	2.40	1.91	4.29	3.72	1.86	1.49
750	5.20	4.50	2.26	1.80	4.05	3.51	1.76	1.41

C/C1- Aluminum Cables in Duct (Per 100′)

Cable Size	C–Magnetic Duct 3 Phase Voltage				C1–Non-Magnetic Duct 3 Phase Voltage			
	208	240	480	600	208	240	480	600
#8	129.00	112.00	56.00	45.00	129.75	112.45	56.20	45.00
6	83.00	72.00	36.00	29.00	80.00	69.10	34.60	27.70
4	53.00	46.00	23.00	18.50	51.10	44.20	22.10	17.70
2	35.00	30.00	15.00	12.00	33.00	25.70	14.30	11.40
1	28.00	24.00	12.00	9.50	26.30	22.80	11.40	9.12
1/0	21.50	18.50	9.70	7.70	21.20	18.40	9.20	7.36
2/0	18.50	16.00	8.00	6.40	17.00	14.70	7.34	5.87
3/0	15.00	13.00	6.50	5.20	13.80	12.00	6.02	4.79
4/0	12.50	11.00	5.50	4.40	11.50	9.95	4.98	3.99
250kcmil	11.10	9.60	4.80	3.85	10.10	8.72	4.36	3.49
300	9.90	8.60	4.30	3.42	8.13	7.04	3.52	2.81
350	8.60	7.40	3.70	3.00	7.49	6.50	3.07	2.45
400	8.30	7.20	3.60	2.90	6.87	5.95	2.98	2.38
500	7.40	6.40	3.20	2.60	6.12	5.31	2.66	2.13
600	7.20	6.20	3.10	2.44	5.30	4.59	2.29	1.83
750	6.50	5.60	2.80	2.22	4.85	4.20	2.10	1.69

Note: For parallel runs divide factor by number of conductors per phase.
Example: If factor for a single 500kcmil conductor is 2.49 then the factor for a run having 3-500kcmil per phase is 2.49 ÷ 3 = .83 (Example from Table B, 480 volts)

Short Circuit Calculations Quick Three Phase

Component Factor Tables - Bus Duct

$$I_{sc} = \frac{120,000}{\text{Total Factor}}$$

D- Factors for Feeder* Bus Duct (Per 100′)

Duct Ampere Rating	Factor 3 Phase Voltage							
	Copper				Aluminum			
	208	240	480	600	208	240	480	600
600	2.85	2.48	1.24	.99	2.54	2.19	1.10	.88
800	1.61	1.40	.70	.56	2.54	2.19	1.10	.88
1000	1.61	1.40	.70	.56	1.90	1.65	.82	.66
1200	1.21	1.06	.53	.42	1.60	1.36	.66	.54
1350	1.17	1.01	.51	.40	1.32	1.14	.57	.46
1600	1.03	.89	.45	.36	1.19	1.03	.52	.41
2000	.90	.78	.39	.31	.90	.77	.39	.31
2500	.63	.54	.27	.22	.70	.60	.30	.24
3000	.51	.44	.22	.18	.60	.52	.26	.21
4000	.37	.32	.16	.13	.43	.38	.19	.15
5000	.30	.26	.13	.10	--	--	--	--

* These factors may be used with feeder duct manufactured by I-T-E, GE, Square D and Westinghouse.

D1- Factors for Plug-In** Bus Duct (Per 100′)

Duct Ampere Rating	Factor 3 Phase Voltage							
	Copper				Aluminum			
	208	240	480	600	208	240	480	600
400	2.53	2.18	1.09	.89	3.88	3.34	1.67	1.36
600	2.53	2.18	1.09	.89	2.41	2.07	1.04	.84
800	1.87	1.61	.81	.66	2.41	2.07	1.04	.84
1000	1.87	1.61	.81	.66	1.69	1.45	.73	.59
1200	1.47	1.26	.63	.51	1.43	1.22	.61	.50
1350	1.26	1.08	.54	.44	1.30	1.12	.56	.45
1600	.91	.78	.39	.32	1.09	.94	.47	.38
2000	.79	.68	.34	.28	.89	.77	.38	.31
2500	.61	.52	.26	.21	.66	.57	.28	.23
3000	.48	.42	.21	.17	.59	.51	.25	.21
4000	.43	.37	.18	.15	.46	.40	.20	.16
5000	.38	.33	.16	.13	.35	.30	.15	.12

** These factors may be used with plug-in duct manufactured by GE, Square D and Westinghouse.