7. ELECTRICAL CHARACTERISTICS

For a wire or cable to perform its intended function reliably, safely and efficiently, the wire or cable must be selected so that its many electrical, physical, chemical and thermal properties match those of the application.

The following sections provide information on some of the most frequently requested electrical parameters.

7.1 DC RESISTANCE OF PLATED COPPER CONDUCTORS

Table 7.1–DC Resistance of Plated Copper Conductors

Wire Size	No. of Wires/Size	Strand	Nominal Area	Nominal DC Resistance ohms/1,000 ft. at 20°C (68°F)		
(AWG/kcmil)	(AWG or in.)	Class	(cmils)	Silver Plated	Nickel Plated	Tin Plated
777	1,952/24	AAR	788,728	–	–	0.0139
750	703/0.0327	H	751,711	–	–	0.0146
750	1,862/24	I	752,267	–	–	0.0146
750	7,448/30	K	744,800	–	–	0.0148
700	703/0.0316	H	701,988	–	–	0.0157
700	1,729/24	I	698,533	–	–	0.0158
700	6,916/30	K	691,600	–	–	0.0165
650	703/0.0304	H	649,684	–	–	0.0169
650	1,596/24	I	644,800	–	–	0.0171
650	6,517/30	K	651,700	–	–	0.0169
646	1,647/24	AAR	665,404	–	–	0.0165
600	703/0.0292	H	599,406	–	–	0.0183
600	1,470/24	I	593,895	–	–	0.0185
600	5,985/30	K	598,500	–	–	0.0184
550	703/0.028	H	551,152	–	–	0.0200
550	1,372/24	I	554,302	–	–	0.0200
550	5,453/30	K	545,300	–	–	0.0200
535	1,332/24	AAR	538,141	–	–	0.0204
500	427/0.0342	H	449,436	–	–	0.0220
500	1,125/24	I	494,912	–	–	0.0222
500	5,054/30	K	505,400	–	–	0.0218
450	427/0.0325	H	451,019	–	–	0.0244
450	1,127/24	I	455,319	–	–	0.0241
450	4,522/30	K	452,200	–	–	0.0243
444	1,110/24	AAR	448,451	–	–	0.025
400	427/0.0306	H	399,826	–	–	0.028
400	980/24	I	395,930	–	–	0.028
400	3,990/30	K	399,000	–	–	0.028
373	925/24	AAR	373,709	–	–	0.029
350	427/0.0286	H	349,269	–	–	0.031

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Table 7.1–DC Resistance of Plated Copper Conductors (Continued)

Wire Size	No. of Wires/Size	Strand	Nominal Area	Nominal DC Resistance ohms/1,000 ft. at 20°C (68°F)		
(AWG/kcmil)	(AWG or in.)	Class	(cmils)	Silver Plated	Nickel Plated	Tin Plated
350	882/24	I	356,337	–	–	0.031
350	3,458/30	K	345,800	–	–	0.032
313	777/24	AAR	313,916	–	–	0.035
300	427/0.0265	H	299,861	–	–	0.037
300	735/24	I	296,947	–	–	0.037
300	2,989/30	K	298,900	–	–	0.037
262	646/24	AAR	260,990	–	–	0.042
250	427/0.0242	H	250,068	–	–	0.043
250	637/24	I	257,354	–	–	0.043
250	2,499/30	K	249,900	–	–	0.044
4/0	2,109/30	K	210,900	0.052	0.053	0.052
4/0	427/0.0223	H	212,343	0.052	0.053	0.052
3/0	1,665/30	K	166,500	0.066	0.067	0.069
3/0	427/0.0198	H	167,401	0.066	0.067	0.066
2/0	1,330/30	K	133,000	0.083	0.084	0.088
2/0	427/0.0177	H	133,775	0.083	0.084	0.082
1/0	1,045/30	K	104,500	0.105	0.107	0.116
1/0	259/0.0202	H	105,682	0.105	0.107	0.103
1	817/30	K	81,700	0.134	0.137	0.144
1	259/0.018	H	83,916	0.134	0.137	0.129
2	665/30	K	66,500	0.165	0.168	0.177
2	259/0.016	H	66,304	0.165	0.168	0.164
2	133/0.0223	H	66,140	0.165	0.168	0.164
3	133/0.0199	H	52,669	0.165	0.168	0.205
4	133/25	H	42,615	0.249	0.259	0.264
5	133/0.0158	H	33,202	0.249	0.259	0.325
6	133/27	H	26,818	0.393	0.409	0.417
8	19/0.0295	C	16,535	0.628	0.689	0.640
8	37/0.0211	D	16,473	0.630	0.692	0.655
8	133/29	H	16,983	0.616	0.642	0.654
10	7/0.0385	B	10,376	1.00	1.10	1.02
10	19/0.0234	C	10,404	1.00	1.10	1.03
10	37/26	D	9,354	1.13	1.18	1.20
12	7/0.0305	B	6,512	1.59	1.75	1.65
12	19/25	C	6,088	1.71	1.78	1.81
12	19/0.0185	C	6,503	1.60	1.75	1.70
12	37/28	D	5,874	1.80	1.87	1.91
12	65/30	K	6,500	1.80	1.87	1.61
14	7/0.0242	B	4,099	2.53	2.69	2.63

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Table 7.1–DC Resistance of Plated Copper Conductors (Continued)

Wire Size	No. of Wires/Size	Strand	Nominal Area	Nominal DC Resistance ohms/1,000 ft. at 20°C (68°F)		
(AWG/kcmil)	(AWG or in.)	Class	(cmils)	Silver Plated	Nickel Plated	Tin Plated
14	19/27	C	3,831	2.70	2.81	2.86
14	19/0.0147	C	4,105	2.62	2.65	2.78
14	37/0.0105	D	4,079	2.62	2.65	2.59
14	41/30	K	4,100	2.62	2.65	2.58
16	7/0.0192	B	2,580	4.02	4.28	4.27
16	19/29	C	2,426	4.23	4.41	4.49
16	19/0.0117	C	2,600	4.14	4.20	4.39
16	26/30	K	2,600	4.14	4.20	4.07
18	7/0.0152	B	1,617	6.58	6.67	6.99
18	7/26	B	1,769	5.86	6.10	6.22
18	16/30	K	1,600	5.86	6.10	6.61
18	19/30	C	1,900	5.38	5.60	5.77
18	19/0.0092	C	1,608	6.69	6.82	7.18
20	7/.28	B	1,111	9.27	9.65	9.84
20	10/30	K	1,000	–	–	10.58
20	19/32	C	1,216	8.53	9.07	9.15
22	7/30	B	700	14.60	15.20	15.60
22	19/34	C	754	13.70	14.60	14.70
24	7/34	B	448	23.10	24.60	24.80
24	19/36	C	475	21.50	22.90	23.10
25	7/0.0067	B	314	33.00	34.80	36.40
26	7/34	B	277	37.10	39.50	39.80
26	19/38	C	304	33.30	36.60	35.70
28	7/36	B	175	58.40	62.10	66.50
28	19/40	C	182	54.60	60.00	58.60
30	7/38	B	112	90.30	99.20	96.20
30	19/42	C	118	82.70	94.00	88.80
32	7/40	B	67	148.0	163.0	159.0
34	7/42	B	43	225.0	256.0	241.5
36	7/44	B	28	244.0	391.0	369.2

Note: AAR – American Association of Railroads
Strand Classes B, C, D, H, I and K per ASTM

7.2 DC AND AC RESISTANCE OF COPPER CONDUCTORS

Table 7.2–DC and AC Resistance of Copper Conductors, Nominal Ohms Per 1,000 ft.

Size	20°C Conductor Temperature	60°C Conductor Temperature			75°C Conductor Temperature			90°C Conductor Temperature		
	DC	DC	60 Hz AC		DC	60 Hz AC		DC	60 Hz AC	
(AWG/kcmil)			*Single Cond.	†Multi-Cond.		*Single Cond.	†Multi-Cond.		*Single Cond.	†Multi-Cond.
40	1,080.0	1,250.0	–	–	1,314.0	–	–	1,378.0	–	–
38	648.6	750.7	–	–	789.1	–	–	827.3	–	–
36	414.8	480.1	–	–	504.6	–	–	529.1	–	–
34	260.9	302.0	–	–	317.4	–	–	332.8	–	–
32	164.1	189.9	–	–	199.6	–	–	209.3	–	–
30	103.2	119.4	–	–	125.5	–	–	131.6	–	–
28	64.9	75.1	–	–	79.0	–	–	82.8	–	–
26	40.8	47.2	–	–	49.7	–	–	52.1	–	–
24	26.1	30.2	–	–	31.8	–	–	33.3	–	–
22	16.4	19.0	–	–	20.0	–	–	20.9	–	–
20	10.3	11.9	–	–	12.5	–	–	13.1	–	–
18	6.54	7.57	–	–	7.96	–	–	8.34	–	–
16	4.1	4.75	–	–	4.99	–	–	5.23	–	–
14	2.57	2.98	2.98	2.98	3.14	3.14	3.14	3.29	3.29	3.29
12	1.62	1.88	1.88	1.88	1.97	1.97	1.97	2.07	2.07	2.07
10	1.17	1.18	1.18	1.18	1.24	1.24	1.24	1.31	1.31	1.31
8	0.638	0.744	0.744	0.744	0.783	0.783	0.783	0.822	0.822	0.822
6	0.403	0.466	0.466	0.466	0.491	0.491	0.491	0.515	0.515	0.515
4	0.253	0.295	0.295	0.295	0.310	0.310	0.31	0.325	0.325	0.325
2	0.159	0.184	0.184	0.185	0.195	0.194	0.196	0.203	0.203	0.205
1	0.126	0.147	0.147	0.148	0.154	0.154	0.155	0.162	0.162	0.163
1/0	0.1	0.116	0.116	0.118	0.122	0.122	0.124	0.128	0.128	0.13
2/0	0.0794	0.0923	0.0923	0.0950	0.0971	0.0971	0.1	0.102	0.102	0.105
3/0	0.0629	0.073	0.073	0.0759	0.0769	0.0769	0.0799	0.0807	0.0807	0.0839
4/0	0.05	0.0579	0.0579	0.0608	0.061	0.061	0.064	0.0639	0.0639	0.0671
250	0.0423	0.049	0.0492	0.0519	0.0516	0.0518	0.0547	0.0541	0.0543	0.0573
300	0.0353	0.0409	0.0411	0.0437	0.0431	0.0433	0.0461	0.0452	0.0454	0.0483

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Table 7.2–DC and AC Resistance of Class B Copper Conductors, ohms per 1,000 ft. (Continued)

Size	20°C Conductor Temperature	60°C Conductor Temperature			75°C Conductor Temperature			90°C Conductor Temperature		
	DC	DC	60 Hz AC		DC	60 Hz AC		DC	60 Hz AC	
(AWG/kcmil)			*Single Cond.	†Multi-Cond.		*Single Cond.	†Multi-Cond.		*Single Cond.	†Multi-Cond.
350	0.0302	0.035	0.0353	0.0378	0.0369	0.0372	0.0398	0.0387	0.0390	0.0418
400	0.0264	0.0307	0.031	0.0338	0.0323	0.0326	0.0355	0.0339	0.0342	0.0373
500	0.0212	0.0246	0.025	0.0278	0.0258	0.0262	0.0291	0.0271	0.0275	0.0306
600	0.0177	0.0205	0.021	0.0238	0.0215	0.022	0.0249	0.0226	0.0231	0.0262
700	0.0151	0.0175	0.0181	0.0208	0.0184	0.019	0.0219	0.0193	0.0199	0.0229
750	0.0141	0.0164	0.0170	0.0198	0.0172	0.0178	0.0208	0.0181	0.0188	0.0219
1,000	0.0106	0.0123	0.0131	0.016	0.0129	0.0137	0.0167	0.0135	0.0144	0.0175
1,250	0.00847	0.00982	0.0108	0.0138	0.0103	0.0113	0.0145	0.0108	0.0119	0.0152
1,500	0.00705	0.00818	0.00934	0.0125	0.00861	0.00983	0.0132	0.00904	0.01030	0.0138
1,750	0.00604	0.00701	0.0083	0.0117	0.00738	0.00874	0.0123	0.00774	0.00917	0.0129
2,000	0.00529	0.00613	0.00755	0.0111	0.00645	0.00795	0.0117	0.00677	0.00835	0.0123
2,500	0.00428	0.00496	–	–	0.00521	–	–	0.00546	–	–
3,000	0.00356	0.00412	–	–	0.00433	–	–	0.00454	–	–
5,000	0.00218	0.00252	–	–	0.00265	–	–	0.00278	–	–

Note: 40 AWG through 26 AWG values are for solid conductors, all others are for ASTM Class B stranded conductors.
*One single conductor in air, buried or in nonmetallic conduit.
†Multiconductor cable or two or three single conductors in one metallic conduit.

Table 7.3–Temperature Correction Factors for Copper DC Resistance

Temperature (°C)	Multiplying Factors for Correction To:	
	20°C	25°C
60	0.864	0.881
75	0.822	0.838
90	0.784	0.800

Example:
The DC resistance of a 500 kcmil copper conductor at 60°C is 0.0246 ohms per 1,000 ft. The resistance at 25°C would be $0.0246 \times 0.881 = 0.0217$ ohms per 1,000 ft.

7.3 DC AND AC RESISTANCE OF ALUMINUM CONDUCTORS

Table 7.4–DC and AC Resistance of Class B Aluminum Conductors, ohms Per 1,000 ft.

Size	60°C Conductor Temperature			75°C Conductor Temperature			90°C Conductor Temperature		
	DC	60 Hz AC		DC	60 Hz AC		DC	60 Hz AC	
(AWG/kcmil)		*Single Cond.	†Multi-Cond.		*Single Cond.	†Multi-Cond.		*Single Cond.	†Multi-Cond.
12	3.08	3.08	3.08	3.24	3.24	3.24	3.40	3.40	3.40
10	1.93	1.93	1.93	2.03	2.03	2.03	2.13	2.13	2.13
8	1.21	1.21	1.21	1.28	1.28	1.28	1.34	1.34	1.34
6	0.765	0.765	0.765	0.080	0.808	0.808	0.848	0.848	0.848
4	0.483	0.483	0.483	0.507	0.507	0.507	0.533	0.533	0.533
3	0.382	0.382	0.382	0.402	0.402	0.402	0.422	0.422	0.422
2	0.303	0.303	0.303	0.319	0.319	0.319	0.335	0.335	0.335
1	0.240	0.240	0.240	0.253	0.253	0.253	0.266	0.266	0.266
1/0	0.191	0.191	0.191	0.201	0.201	0.201	0.211	0.211	0.211
2/0	0.151	0.151	0.151	0.159	0.159	0.159	0.167	0.167	0.167
3/0	0.119	0.119	0.120	0.126	0.126	0.127	0.132	0.132	0.133
4/0	0.0953	0.0954	0.0963	0.101	0.101	0.102	0.106	0.106	0.107
250	0.0806	0.0808	0.0822	0.0848	0.0850	0.0865	0.0890	0.0892	0.0908
300	0.0672	0.0674	0.0686	0.0706	0.0708	0.0720	0.0741	0.0744	0.0756
350	0.0575	0.0578	0.0593	0.0605	0.0608	0.0623	0.0635	0.0638	0.0654
400	0.0504	0.0507	0.0525	0.0500	0.0533	0.0552	0.0557	0.0560	0.0580
500	0.0403	0.0406	0.0428	0.0424	0.0427	0.0450	0.0445	0.0448	0.0472
600	0.0336	0.0340	0.0370	0.0353	0.0357	0.0381	0.0370	0.0374	0.0400
700	0.0288	0.0292	0.0320	0.0303	0.0307	0.0337	0.0318	0.0322	0.0353
750	0.0269	0.0273	0.0302	0.0283	0.0288	0.0317	0.0297	0.0302	0.0333
1,000	0.0201	0.0207	0.0239	0.0212	0.0218	0.0253	0.0222	0.0228	0.0265
1,250	0.0162	0.0176	0.0215	0.0170	0.0177	0.0216	0.0179	0.0186	0.0228
1,500	0.0135	0.0143	0.0184	0.0142	0.0150	0.0193	0.0149	0.0158	0.0203
1,750	0.0115	0.0124	0.0168	0.0121	0.0131	0.0177	0.0127	0.0137	0.0186
2,000	0.0101	0.0111	0.0158	0.0106	0.0117	0.0165	0.0111	0.0122	0.0173

*One single conductor in air, buried or in nonmetallic conduit.
†Multiconductor cable or two or three single conductors in one metallic conduit.

Table 7.5–Temperature Correction Factors for Aluminum DC Resistance

Temperature (°C)	Multiplying Factors for Correction To:	
	20°C	25°C
60	0.861	0.878
75	0.818	0.835
90	0.780	0.796

Example:
The DC resistance of a 500 kcm aluminum conductor at 60°C is 0.0403 ohms per 1,000 ft. The resistance at 25°C would be $0.0403 \times 0.878 = 0.0354$ ohms per 1,000 ft.

7.4 REACTANCE AND IMPEDANCE AT 60 Hz

Table 7.6–Reactance and Impedance at 60 Hz for Single Copper Conductor Cables Installed in Air, Buried or in Separate Nonmetallic Conduits

Conductor Size	Approximate ohms per 1,000 ft. per Conductor at 25°C (77°F)							
	Distance Between Centers of Conductors							
	2 in.		4 in.		6 in.		8 in.	
(AWG/kcmil)	Reactance	Impedance	Reactance	Impedance	Reactance	Impedance	Reactance	Impedance
8	0.0816	0.659	0.0976	0.661	0.1070	0.662	0.1135	0.664
6	0.0764	0.417	0.0922	0.420	0.1016	0.422	0.1082	0.424
4	0.0710	0.255	0.0868	0.261	0.0962	0.264	0.1025	0.267
3	0.0682	0.216	0.0842	0.221	0.0934	0.225	0.1000	0.228
2	0.0656	0.175	0.0815	0.181	0.0908	0.186	0.0974	0.189
1	0.0627	0.143	0.0787	0.151	0.0880	0.156	0.0945	0.160
1/0	0.0600	0.118	0.0760	0.127	0.0853	0.133	0.0918	0.137
2/0	0.0598	0.0993	0.0732	0.109	0.0826	0.116	0.0892	0.121
3/0	0.0573	0.0884	0.0706	0.0954	0.0799	0.103	0.0866	0.108
4/0	0.0520	0.0728	0.0680	0.0850	0.0773	0.0926	0.0840	0.0982
250	0.0500	0.0661	0.0660	0.0789	0.0753	0.0869	0.0819	0.0926
300	0.0481	0.0602	0.0640	0.0734	0.0732	0.0816	0.0798	0.0876
350	0.0462	0.0557	0.0622	0.0695	0.0715	0.0779	0.0780	0.0840
400	0.0445	0.0522	0.0606	0.0664	0.0700	0.0750	0.0766	0.0814
500	0.0422	0.0476	0.0581	0.0621	0.0674	0.0709	0.0740	0.0772
600	0.0400	0.0441	0.0559	0.0588	0.0652	0.0678	0.0718	0.0741
700	0.0380	0.0412	0.0539	0.0561	0.0633	0.0652	0.0700	0.0718
750	0.0376	0.0404	0.0534	0.0554	0.0628	0.0645	0.0694	0.0710

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Table 7.6–Reactance and Impedance at 60 Hz for Single Copper Conductor Cables Installed in Air, Buried or in Separate Nonmetallic Conduits (Continued)

Conductor Size	Approximate ohms per 1,000 ft. per Conductor at 25°C (77°F)							
	Distance Between Centers of Conductors							
	2 in.		4 in.		6 in.		8 in.	
(AWG/kcmil)	Reactance	Impedance	Reactance	Impedance	Reactance	Impedance	Reactance	Impedance
800	0.0370	0.0396	0.0527	0.0546	0.0621	0.0636	0.0687	0.0701
900	0.0354	0.0376	0.0512	0.0527	0.0606	0.0619	0.0673	0.0685
1,000	0.0342	0.0360	0.0500	0.0512	0.0594	0.0605	0.0660	0.0670
1,250	0.0314	0.0328	0.0472	0.0481	0.0566	0.0574	0.0632	0.0639
1,500	0.0296	0.0307	0.0453	0.0460	0.0548	0.0554	0.0614	0.0619
1,750	0.0276	0.0285	0.0434	0.0440	0.0527	0.0532	0.0593	0.0597
2,000	0.0264	0.0272	0.0422	0.0427	0.0514	0.0518	0.0582	0.0585

For equations that can be used to calculate inductive reactance for other conductor spacings, see Section 18.10.

7.5 AC/DC RESISTANCE RATIO AT 60 Hz

Table 7.7–AC/DC Resistance Ratio at 60 Hz

To determine effective 60 Hz AC resistance, multiply DC resistance values corrected for proper temperature by the AC/DC resistance ratio given below.

Conductor Size (AWG/kcmils)	Single Copper Conductors in Air, or in Individual Nonmetallic Conduits	Multiple Copper Conductor Cable or Two or Three Single Conductor Cables in Same Metallic Conduit
Up to 3	1.00	1.00
2 and 1	1.00	1.01
1/0	1.00	1.02
2/0	1.00	1.03
3/0	1.00	1.04
4/0	1.00	1.05
250	1.005	1.06
300	1.006	1.07
350	1.009	1.08
400	1.011	1.10
500	1.018	1.13
600	1.025	1.16
700	1.034	1.19
750	1.039	1.21
800	1.044	–
1,000	1.067	–
1,250	1.102	–
1,500	1.142	–
1,750	1.185	–
2,000	1.233	–

Source: Underground Systems Reference Book, Edison Electric Institute, 1957.

The single conductor column in the table above covers single conductor nonshielded cable having spacing of six inches or more including all conditions of use except when two or more cables are pulled into the same metallic or nonmetallic conduit.

The multiple conductor column in the table above covers the following conditions:

(a) Single conductor cable; two or three cables in the same metallic conduit.
(b) Single conductor shielded cable; two or three cables in the same metallic or nonmetallic duct or conduit, but only with conductor sizes up to 250 kcmils. For larger conductor sizes the short-circuited sheath losses increase rapidly and the table above does not apply.
(c) Three conductor nonshielded cable; one cable in metal conduit.
(d) Three conductor shielded cable; all conditions of use in air, in ducts and in conduit.

The table represents maximum AC losses for the conditions outlined.

7.6 TEMPERATURE CORRECTION FACTORS FOR RESISTANCE

Table 7.8–Temperature Correction Factors for the Resistance of Copper Conductors

Temp°C	Multiplying Factor
25	1.000
40	1.058
50	1.096
55	1.116
60	1.135
65	1.154
70	1.173
75	1.193
80	1.212
85	1.231
90	1.250
100	1.289
105	1.308
125	1.385
130	1.404
150	1.482
200	1.674

The DC resistance of copper wire increases with increasing temperature in accordance with the formula:

$$R_t = R_0 [1 + a (T - T_0)]$$

Where:

R_t = Resistance at temperature T

R_0 = Resistance at temperature T_0

a = Temperature coefficient of resistance at T_0 [At 20°C (68°F) the temperature coefficient of copper is 0.00393 per degree Celsius

7.7 VOLTAGE DROP

The values in Tables 7.9 for copper conductors and 7.10 for aluminum conductors are calculated at 60°C, the estimated average temperature that may be anticipated in service. They may be used without significant error for conductor temperatures up to and including 75°C. For 90°C multiply by 1.102 for copper and by 1.105 for aluminum. To obtain values for other circuits, multiply by 1.155 for single-phase line-to-line and by 0.577 for single- or three-phase line-to-neutral.

$$\text{Voltage drop} = \frac{\text{Table value} \times \text{Current in amps} \times \text{Length of circuit in feet}}{100}$$

$$\text{Voltage drop in percent} = \frac{\text{Voltage drop in V} \times 100}{\text{Circuit voltage in V}}$$

Table 7.9–Phase-to-Phase Voltage Drop Per Amp Per 100 ft. of Circuit for a Three-Phase, 60 Hz System Operating at 60°C with Copper Conductors

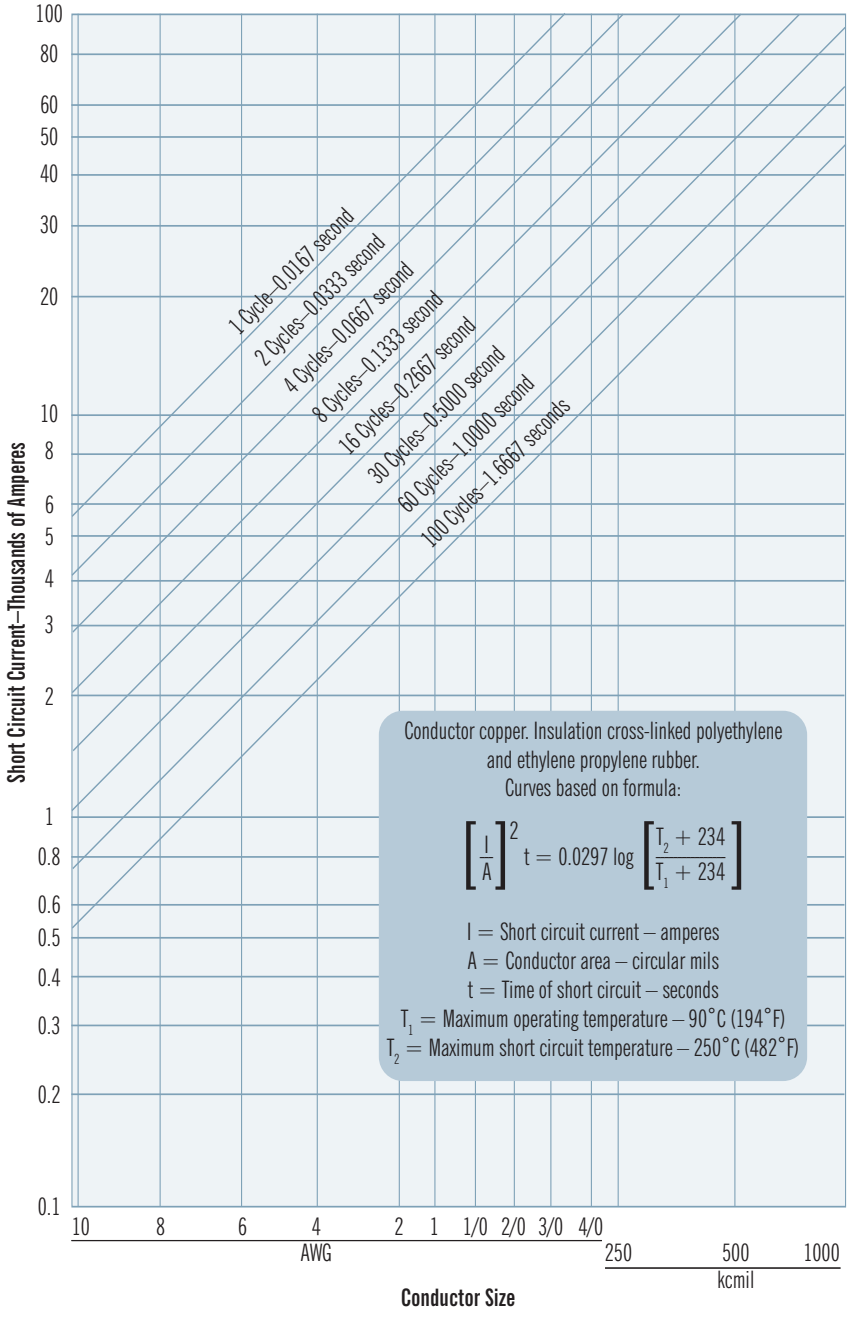
Size	In Non-Magnetic Conduit			In Magnetic Conduit		
	Percent Power Factor			Percent Power Factor		
(AWG/kcmil)	80	90	100	80	90	100
12	0.2710	0.3030	0.3330	0.2720	0.3030	0.3320
10	0.1710	0.1910	0.2080	0.1720	0.1910	0.2080
8	0.1090	0.1200	0.1300	0.1100	0.1210	0.1300
6	0.0720	0.0790	0.0840	0.0730	0.0800	0.0840
4	0.0470	0.0510	0.0530	0.0480	0.0520	0.0530
2	0.0310	0.0330	0.0330	0.0320	0.0340	0.0340
1	0.0260	0.0270	0.0260	0.0260	0.0280	0.0260
1/0	0.0210	0.0220	0.0210	0.0220	0.0230	0.0210
2/0	0.0170	0.0180	0.0160	0.0190	0.0190	0.0170
3/0	0.0140	0.0150	0.0130	0.0160	0.0160	0.0140
4/0	0.0120	0.0120	0.0100	0.0140	0.0130	0.0110
250	0.0110	0.0110	0.0088	0.0120	0.0120	0.0093
300	0.0097	0.0095	0.0073	0.0110	0.0110	0.0078
350	0.0088	0.0085	0.0062	0.0100	0.0095	0.0067
400	0.0081	0.0076	0.0055	0.0095	0.0088	0.0061
500	0.0073	0.0067	0.0045	0.0085	0.0078	0.0050
600	0.0066	0.0059	0.0038	0.0080	0.0071	0.0042
700	0.0062	0.0055	0.0033	0.0074	0.0066	0.0037
750	0.0059	0.0054	0.0029	0.0073	0.0064	0.0035
1,000	0.0050	0.0043	0.0023	0.0066	0.0055	0.0023

Table 7.10–Phase-To-Phase Voltage Drop Per Amp Per 100 ft. of Circuit for a Three-Phase, 60 Hz System Operating at 60°C with Aluminum Conductors

Size	In Non-Magnetic Conduit			In Magnetic Conduit		
	Percent Power Factor			Percent Power Factor		
(AWG/kcmil)	80	90	100	80	90	100
12	0.4240	0.4750	0.5230	0.4260	0.4760	0.5230
10	0.2680	0.2990	0.3290	0.2690	0.2140	0.3290
8	0.1700	0.1890	0.2070	0.1720	0.1910	0.2070
6	0.1110	0.1230	0.1330	0.1120	0.1230	0.1320
4	0.0710	0.0780	0.0830	0.0730	0.0790	0.0840
2	0.0460	0.0500	0.0520	0.0470	0.0510	0.0520
1	0.0380	0.0400	0.0420	0.0390	0.0410	0.0420
1/0	0.0310	0.0330	0.0330	0.0320	0.0340	0.0330
2/0	0.0250	0.0260	0.0260	0.0260	0.0270	0.0260
3/0	0.0210	0.0220	0.0210	0.0220	0.0230	0.0210
4/0	0.0170	0.0180	0.0170	0.0180	0.0180	0.0170
250	0.0150	0.0150	0.0140	0.0160	0.0160	0.0140
300	0.0130	0.0130	0.0120	0.0140	0.0140	0.0120
350	0.0120	0.0120	0.0099	0.0130	0.0130	0.0100
400	0.0110	0.0110	0.0087	0.0120	0.0120	0.0091
500	0.0092	0.0089	0.0070	0.0100	0.0099	0.0074
600	0.0083	0.0079	0.0059	0.0095	0.0088	0.0062
700	0.0076	0.0071	0.0050	0.0088	0.0082	0.0055
750	0.0073	0.0068	0.0048	0.0085	0.0079	0.0052
1,000	0.0068	0.0063	0.0042	0.0077	0.0069	0.0042

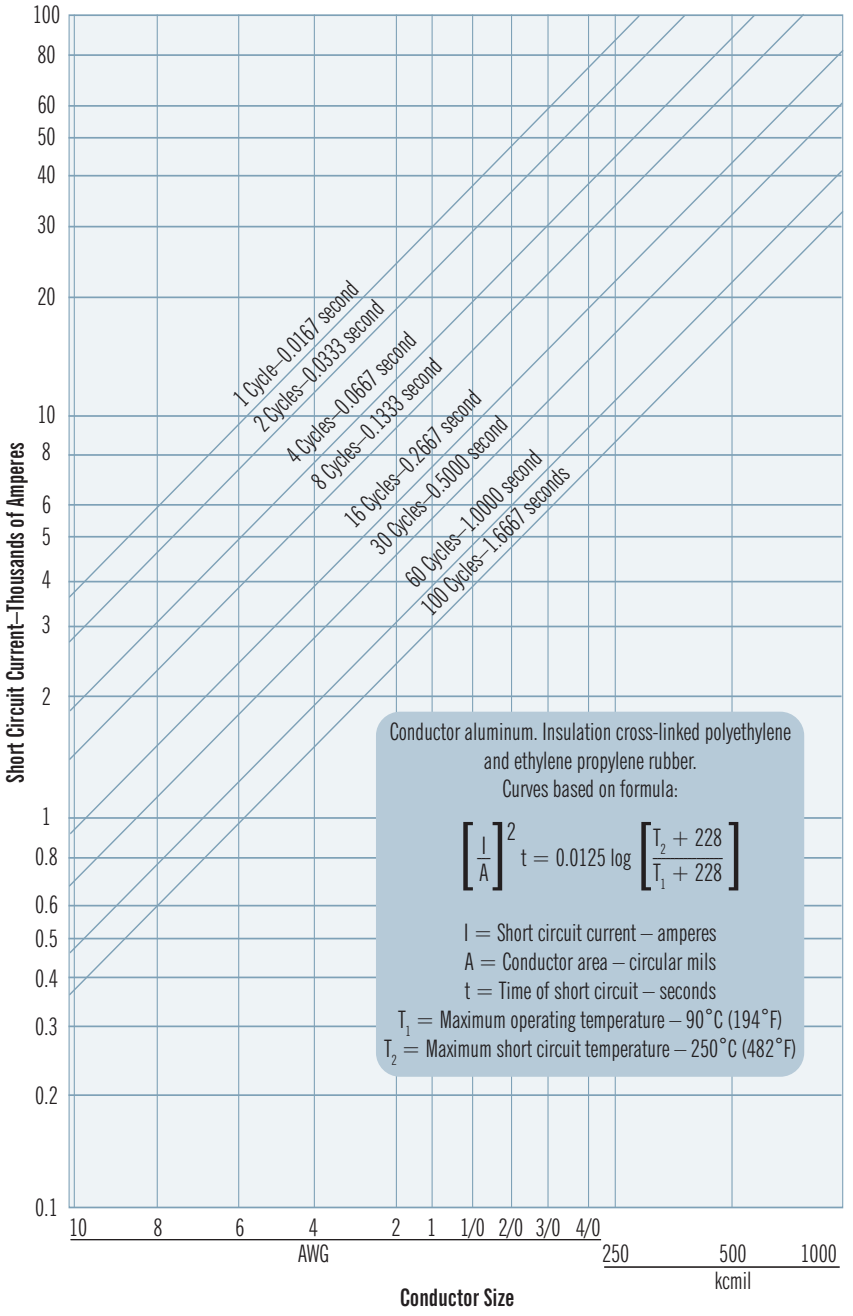
7.8 MAXIMUM CONDUCTOR SHORT CIRCUIT CURRENT

Because of the high kilovolt-ampere (kVA) capacity of many power systems, possible short circuit currents must be considered in power system design. A cable's maximum short circuit current rating is the maximum allowable current that the cable can withstand without damage. The maximum allowable short circuit current for copper and aluminum conductors can be determined with the aid of Figures 7.1 and 7.2, respectively.



Source: ICEA P-32-382

Figure 7.1–Maximum Conductor Short Circuit Current for Copper Cables



Source: ICEA P-32-382

Figure 7.2–Maximum Conductor Short Circuit Current for Aluminum Cables

7.9 MAXIMUM SHIELD SHORT CIRCUIT CURRENT

Table 7.11–Maximum Short Circuit Current for Copper Shielding Tape (Amperes)

Shield Dia.	Effective Shield Area	Short Circuit Time (Number of Cycles at 60 Hz)						
(in.)	(cmils)	1	2	4	8	16	30	60
1/2	7,484	4,016	2,840	2,008	1,420	1,004	733	518
3/4	11,264	6,044	4,274	3,022	2,137	1,511	1,104	780
1	15,044	8,073	5,708	4,036	2,854	2,018	1,474	1,042
1 1/4	18,824	10,101	7,143	5,051	3,571	2,525	1,844	1,304
1 1/2	22,604	12,130	8,577	6,065	4,289	3,032	2,215	1,566
1 3/4	26,384	14,158	10,011	7,079	5,006	3,540	2,585	1,828
2	30,164	16,187	11,446	8,093	5,723	4,047	2,955	2,090
2 1/4	33,944	18,215	12,880	9,107	6,440	4,554	3,326	2,352
2 1/2	37,724	20,243	14,314	10,122	7,157	5,061	3,696	2,613
2 3/4	41,504	22,272	15,749	11,136	7,874	5,568	4,066	2,875
3	45,284	24,300	17,183	12,150	8,591	6,075	4,437	3,137

Source: ICEA P-45-482

Information in this chart is based on initial temperature of 65°C, final temperature of 200°C, 5 mil copper tape with 12.5 percent overlap.

7.10 RESISTANCE AND AMPACITY AT 400 AND 800 HZ

Table 7.12–400 and 800 Hz Ampacity Factors for 600 V Copper Cables with Class B Strand, Installed with Minimum Triangular Spacing in Air or in Nonmetallic Conduit

				400 Hz		800 Hz	
Conductor Size (AWG/kcmil)	Conductor Diameter (in.)	Cable Diameter (in.)	DC Resistance 75°C (ohms/1,000 ft.)	AC/DC Resistance Ratio	Ampacity Derating Factor*	AC/DC Resistance Ratio	Ampacity Derating Factor*
14	0.073	0.21	3.14	1.00	1.00	1.00	1.00
12	0.092	0.23	1.97	1.00	1.00	1.00	1.00
10	0.116	0.25	1.24	1.00	1.00	1.00	1.00
8	0.146	0.32	0.780	1.00	1.00	1.00	1.00
6	0.184	0.39	0.490	1.00	1.00	1.00	1.00
4	0.232	0.44	0.310	1.00	1.00	1.05	0.98
2	0.292	0.50	0.194	1.03	0.98	1.12	0.94
1	0.332	0.61	0.154	1.05	0.98	1.16	0.93
1/0	0.372	0.65	0.122	1.08	0.96	1.25	0.89
2/0	0.418	0.69	0.097	1.15	0.93	1.40	0.84
3/0	0.470	0.75	0.0767	1.22	0.90	1.53	0.81
4/0	0.528	0.81	0.0608	1.33	0.87	1.70	0.77
250	0.575	0.92	0.0515	1.40	0.84	1.82	0.74
350	0.681	1.08	0.0368	1.56	0.80	2.05	0.70
500	0.813	1.16	0.0258	1.90	0.72	2.54	0.63
750	0.998	1.38	0.0172	2.30	0.66	3.06	0.57
1,000	1.152	1.54	0.0129	2.60	0.62	3.44	0.54

Source: ICEA P-43-457

* These derating factors do not apply to cables with metallic sheath or armor, nor to cables installed in conduit or adjacent to steel structures. Ampacity equals the 60 Hz ampacity multiplied by the derating factor.

7.11 CURRENT RATINGS FOR ELECTRONIC CABLES

The maximum continuous current rating for an electronic cable is limited by conductor size, number of conductors contained within the cable, maximum temperature rating of the cable and environmental conditions such as ambient temperature and airflow. To use the current capacity chart (Figure 7.3), first determine conductor gauge, temperature rating and number of conductors for the cable of interest.

Next, find the current value on the chart for the applicable temperature rise (temperature rating of cable minus ambient temperature) and conductor size. To calculate the maximum current rating per conductor, multiply the chart value by the appropriate conductor factor. The chart assumes the cable is surrounded by still air at an ambient temperature of 25°C. Current values are in RMS amperes and are valid for copper conductors only.

Note: Current ratings are intended as general guidelines for low power, electronic communications and control applications. Current ratings for power applications are published by codes and standards groups including NEC, UL, CSA, ICEA, NEMA, IEEE and IEC.

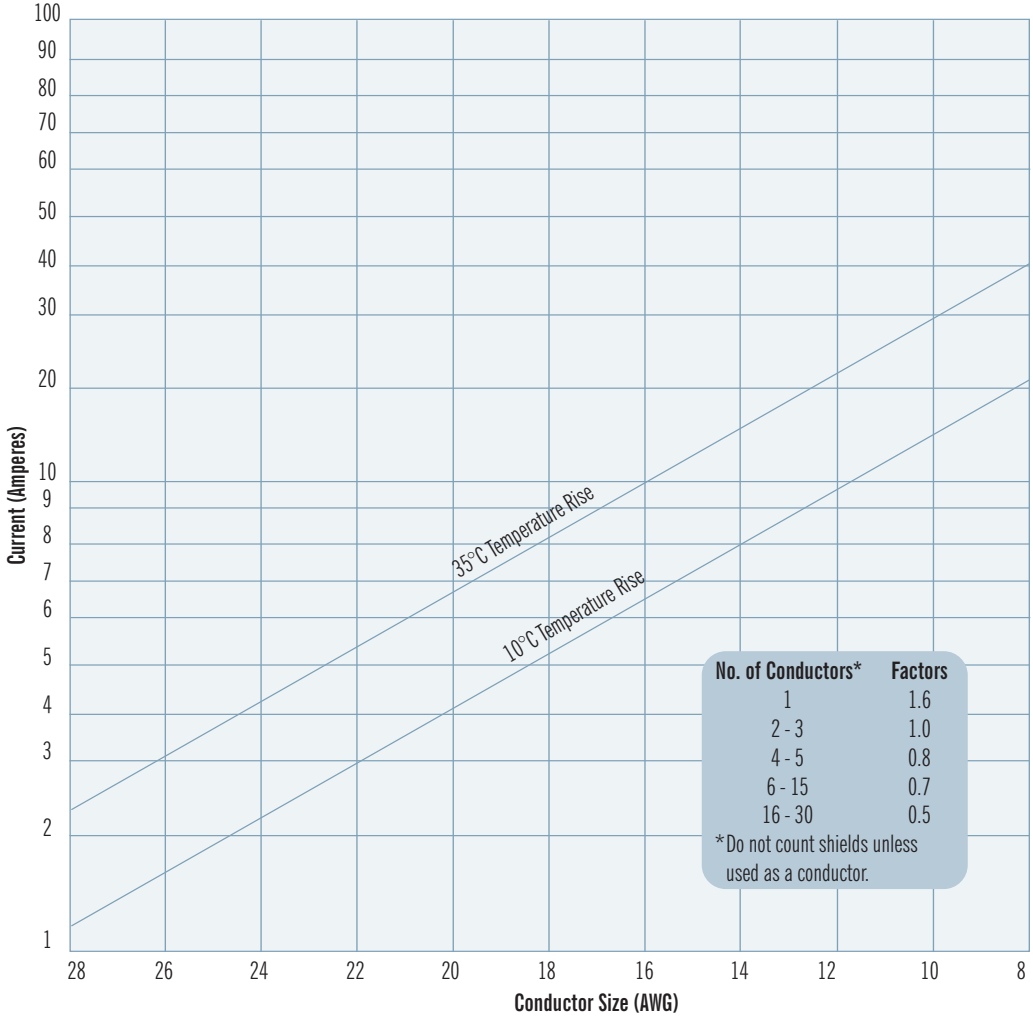


Figure 7.3–Current Ratings for Electronic Cables

7.12 AMPACITY OF POWER CABLES

The ampacity of a power cable depends primarily on its conductor size, conductor material (e.g., copper or aluminum), temperature rating, ambient temperature, installed cable configuration and other factors. Because so many external conditions affect ampacity, tables covering all situations are not possible. However, tables covering many common situations are available. Frequently used ampacity tables are contained in the following publications:

NFPA Standard 70 National Electrical Code
CSA Standard C22.1 Canadian Electrical Code
IEEE Standard 835 Power Cable Ampacity Tables
ICEA P-53-426 (NEMA WC 50) Ampacities Including Shield Losses for 15 Through 69 kV Cables
ICEA P-54-440 (NEMA WC 51) Ampacities of Cables in Open-Top Cable Trays
IEEE Standard 45 Recommended Practice for Installations on Shipboard

7.13 BASIC IMPULSE LEVEL (BIL) RATINGS

Electrical equipment, including wire and cable, is designed to withstand short-term, but very high-voltage pulses such as those sometimes caused by lightning and switching surges. These "spikes," as they are sometimes called, typically have a risetime in the range of 1.5 microseconds and a falltime around 40 microseconds. The basic impulse level (BIL) is the maximum impulse voltage that a cable is designed to withstand. Common BIL ratings are shown below.

Table 7.13–Basic Impulse Level (BIL) Ratings

System Voltage Rating (kV)	Basic Impulse Level (kV)
2.5	60
5.0	75
8.0	95
15.0	110
25.0	150
35.0	200
69.0	350
138.0	650

Source: IEEE 82 Impulse Voltage Tests on Insulated Conductors