Point-To-Point Method Of Short-Circuit Calc

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Calculation Of Short-Circuit Currents — Point-To-Point Method.

Adequate interrupting rating and protection of electrical components are two essential aspects required by the NEC® 110.3(B), 110.9, 110.10, 240.1, 250.4, 250.90, 250.96, and Table 250.122 Note.
The first step to ensure that system protective devices have the proper interrupting rating and provide component protection is to determine the available short-circuit currents. The application of the Point-To-Point method can be used to determine the available short-circuit currents with a reasonable degree of accuracy at various points for either 3ϕ or 1ϕ electrical distribution systems. The example shown here assumes unlimited primary short-circuit current (infinite bus).

Basic Short-Circuit Calculation Procedure.

Procedure		Formula
Step 1	Determine transf. full-load amperes from either: a) Name plate b) Tables 3A & 3B c) Formula	3ϕ transf. $I_{FLA} = \frac{KVA \times 1000}{E_{L-L} \times 1.732}$
		1ϕ transf. $I_{FLA} = \frac{KVA \times 1000}{E_{L-L}}$
Step 2	Find transformer multiplier See Note 3.	$\text{Multiplier} = \frac{100}{\text{Transf. } \%Z}$
Step 3	Determine transf. let-through short-circuit current (Formula or Table 5) See Note 1 and Note 4.	$^{\dagger}I_{SCA} = \text{Transf.}_{FLA} \times \text{multiplier}$
Step 4	Calculate "f" factor.	3ϕ faults $f = \frac{1.732 \times L \times I_{L-L-L}}{C \times n \times E_{L-L}}$
		1ϕ line-to-line (L-L) faults See Note 5 $f = \frac{2 \times L \times I_{L-L}}{C \times n \times E_{L-L}}$
		1ϕ line-to-neutral (L-N) faults See Note 2 and Note 5 $f = \frac{2 \times L \times I_{L-N}^{*}}{C \times n \times E_{L-N}}$
		L = length (feet) of conduit to the fault. **C** = conductor constant. See Tables 1, 2. **n** = number of conductors per phase (Adjusts C value for parallel runs) **I** = available short-circuit current in amperes at beginning of circuit.
Step 5	Calculate "M" (multiplier) or take from Table 4.	$M = \frac{1}{1 + f}$
Step 6	Compute the available short-circuit current (RMS symmetrical) See Note 1, Note 2, and Note 5	$^{\dagger}I_{SCA} = I_{SCA} \times M$ (at fault = at beginning of circuit.)

† **Note 1.** Motor short-circuit contribution, if significant, should be added at all fault locations throughout the system. A practical estimate of motor short-circuit contribution is to multiply the total motor full-load current in amperes by 4. Values of 4 to 6 are commonly accepted

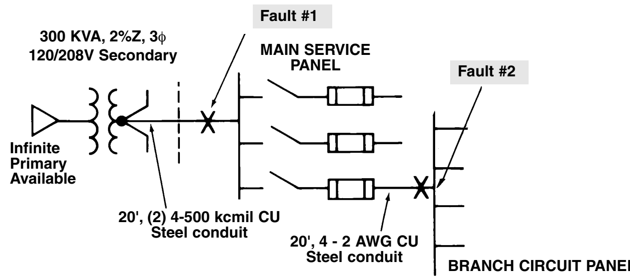
* **Note 2.** For single-phase center-tapped transformers, the L-N fault current is higher than the L-L fault current at the secondary terminals. The short-circuit current available (I) for this case in Step 4 should be adjusted at the transformer terminals as follows:

At L-N center tapped transformer terminals

$I_{L-N} = 1.5 \times I_{L-L}$ at Transformer Terminals

At some distance from the terminals, depending upon wire size, the L-N fault current is lower than the L-L fault current. The 1.5 multiplier is an approximation and will theoretically vary from 1.33 to 1.67. These figures are based on change in turns ratio between primary and secondary, infinite source available, zero feet from terminals of transformer, and 1.2 x %X and 1.5 x %R for L-N vs. L-L resistance and reactance values. Begin L-N calculations at transformer secondary terminals, then proceed point-to-point.

Example Of 3-Phase Short-Circuit Calculation



FAULT #1

Step 1 $I_{FLA} = \frac{KVA \times 1000}{E_{L-L} \times 1.732} = \frac{300 \times 1000}{208 \times 1.732} = 833A$

Step 2 $\text{Multiplier} = \frac{100}{^{\dagger\dagger}.9 \times \text{Transf. } \%Z} = \frac{100}{1.8} = 55.55$

Step 3 $^{**}I_{SCA\ (L-L-L)} = 833 \times 55.55 = 46{,}273$
3-Phase Short-Circuit Current at Transformer Secondary

Step 4 $f = \frac{1.732 \times L \times I_{L-L-L}}{C \times n \times E_{L-L}} = \frac{1.732 \times 20 \times 46{,}273}{22{,}185 \times 2 \times 208} = .174$

Step 5 $M = \frac{1}{1 + f} = \frac{1}{1 + .174} = .852$ (See Table 4)

Step 6 $^{\dagger}I_{SCA\ (L-L-L)} = 46{,}273 \times .852 = 39{,}425A$
3-Phase Short Circuit Current at Fault #1

FAULT #2 (Use $I_{SCA\ (L-L-L)}$ at Fault #1 to calculate)

Step 4 $f = \frac{1.732 \times 20 \times 39{,}425}{5{,}907 \times 1 \times 208} = 1.11$

Step 5 $M = \frac{1}{1 + f} = \frac{1}{1 + 1.11} = .474$ (See Table 4)

Step 6 $^{\dagger}I_{SCA\ (L-L-L)} = 39{,}425 \times .474 = 18{,}687A$
3-Phase Short-Circuit Current at Fault #2

**The motor contribution and voltage variance should be accounted for at this point. See Notes 1 and 4.

††Transformer %Z is multiplied by .9 to establish a worst case condition. See Note 3.

Note 3: The marked impedance values on transformers may vary ±10% from the actual values determined by ANSI / IEEE test. See U.L. Standard 1561. Therefore, multiply transformer %Z by .9. Transformers constructed to ANSI standards have a ± 7.5% impedance tolerance (two-winding construction).

Note 4. Utility voltages may vary ±10% for power, and ±5.8% for 120-volt lighting services. Therefore, for worst case conditions, multiply values as calculated in Step 3 by 1.1 and/or 1.058 respectively.

Note 5: The calculated short-circuit currents above represent the bolted fault values that approximate worst case conditions. Approximations of Bolted fault values as percentage of 3-Phase (L-L-L) bolted fault values are shown below.

Phase-Phase (L-L):	87%
Phase-Ground (L-G)	25-125% (Use 100% near transformer, 50% otherwise)
Phase-Neutral (L-N)	25-125% (Use 100% near transformer, 50% otherwise)

Note 6: Approximation of arcing fault values for sustained arcs as percentage of 3-Phase (L-L-L) bolted fault values are shown below.

3-Phase (L-L-L) Arching Fault	89% (maximum)
Phase-Phase (L-L) Arcing Fault	74% (maximum)
Phase-Ground (L-G) Arcing Fault	38% (minimum)

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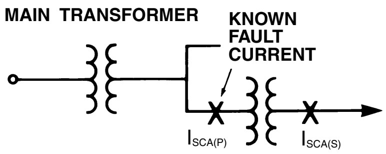
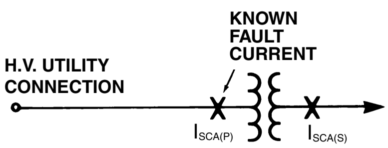
Calculation Of Short-Circuit Currents At Second Transformer In System.

Use the following procedure to calculate the level of fault current at the secondary of a second, downstream transformer in a system when the level of fault current at the transformer primary is known.





Procedure For Second Transformer in System

Procedure		Formula	
Step A	Calculate "f" ($I_{SCA(P)}$, known).	3ϕ transformer ($I_{SCA(P)}$ and $I_{SCA(S)}$ are 3ϕ fault values).	$f = \dfrac{I_{SCA(P)} \times V_P \times 1.732\ (\%Z)}{100{,}000 \times KVA}$
		1ϕ transformer ($I_{SCA(P)}$ and $I_{SCA(S)}$ are 1ϕ fault values; $I_{SCA(S)}$ is L-L.)	$f = \dfrac{I_{SCA(P)} \times V_P \times (\%Z)}{100{,}000 \times KVA}$
Step B	Calculate "M" (multiplier) or take from Table 4.	$M = \dfrac{1}{1 + f}$	
Step C	Calculate short-circuit current at secondary of transformer. (See Note 1 under "Basic Procedure")	$I_{SCA(S)} = \dfrac{V_P}{V_S} \times M \times I_{SCA(P)}$	

$I_{SCA(P)}$ = Available fault current at transformer primary.
$I_{SCA(S)}$ = Available fault current at transformer secondary.
V_P = Primary voltage L-L.
V_S = Secondary voltage L-L.

KVA = KVA rating of transformer.
%Z = Percent impedance of transformer.
Note: To calculate fault level at the end of a conductor run, follow Steps 4, 5, and 6 of Basic Procedure.

Table 1. "C" Values for Busway

Ampacity	Busway				
	Plug-In	Feeder		High Impedance	
	Copper	Aluminum	Copper	Aluminum	Copper
225	28700	23000	18700	12000	—
400	38900	34700	23900	21300	—
600	41000	38300	36500	31300	—
800	46100	57500	49300	44100	—
1000	69400	89300	62900	56200	15600
1200	94300	97100	76900	69900	16100
1350	119000	104200	90100	84000	17500
1600	129900	120500	101000	90900	19200
2000	142900	135100	134200	125000	20400
2500	143800	156300	180500	166700	21700
3000	144900	175400	204100	188700	23800
4000	—	—	277800	256400	—

Note: These values are equal to one over the impedance per foot for impedance in a survey of industry.

Table 3A. Three-Phase Transformer—Full-Load Current Rating (In Amperes)

Voltage (Line-to-Line)	Transformer KVA Rating 45	75	112.5	150	225	300	500	750	1000	1500	2000
208	125	208	312	416	625	833	1388	2082	2776	4164	5552
220	118	197	295	394	590	787	1312	1968	2624	3937	5249
240	108	180	271	361	541	722	1203	1804	2406	3609	4811
440	59	98	148	197	295	394	656	984	1312	1968	2624
460	56	94	141	188	282	377	628	941	1255	1883	2510
480	54	90	135	180	271	361	601	902	1203	1804	2406
600	43	72	108	144	217	289	481	722	962	1443	1925

Table 3B. Single-Phase Transformer—Full-Load Current Rating (In Amperes)

Voltage	Transformer KVA Rating 25	50	75	100	167	250	333	500
115/230	109	217	326	435	726	1087	1448	2174
120/240	104	208	313	417	696	1042	1388	2083
230/460	54	109	163	217	363	543	724	1087
240/480	52	104	156	208	348	521	694	1042

Table 2. "C" Values for Conductors

Copper AWG or kcmil	Three Single Conductors, Conduit, Steel 600V	5kV	15kV	Nonmagnetic 600V	5kV	15kV	Three-Conductor Cable, Conduit, Steel 600V	5kV	15kV	Nonmagnetic 600V	5kV	15kV
14	389	-	-	389	-	-	389	-	-	389	-	-
12	617	-	-	617	-	-	617	-	-	617	-	-
10	981	-	-	982	-	-	982	-	-	982	-	-
8	1557	1551	-	1559	1555	-	1559	1557	-	1560	1558	-
6	2425	2406	2389	2430	2418	2407	2431	2425	2415	2433	2428	2421
4	3806	3751	3696	3826	3789	3753	3830	3812	3779	3838	3823	3798
3	4774	4674	4577	4811	4745	4679	4820	4785	4726	4833	4803	4762
2	5907	5736	5574	6044	5926	5809	5989	5930	5828	6087	6023	5958
1	7293	7029	6759	7493	7307	7109	7454	7365	7189	7579	7507	7364
1/0	8925	8544	7973	9317	9034	8590	9210	9086	8708	9473	9373	9053
2/0	10755	10062	9390	11424	10878	10319	11245	11045	10500	11703	11529	11053
3/0	12844	11804	11022	13923	13048	12360	13656	13333	12613	14410	14119	13462
4/0	15082	13606	12543	16673	15351	14347	16392	15890	14813	17483	17020	16013
250	16483	14925	13644	18594	17121	15866	18311	17851	16466	19779	19352	18001
300	18177	16293	14769	20868	18975	17409	20617	20052	18319	22525	21938	20163
350	19704	17385	15678	22737	20526	18672	22646	21914	19821	24904	24126	21982
400	20566	18235	16366	24297	21786	19731	24253	23372	21042	26916	26044	23518
500	22185	19172	17492	26706	23277	21330	26980	25449	23126	30096	28712	25916
600	22965	20567	17962	28033	25204	22097	28752	27975	24897	32154	31258	27766
750	24137	21387	18889	29735	26453	23408	31051	30024	26933	34605	33315	29735
1,000	25278	22539	19923	31491	28083	24887	33864	32689	29320	37197	35749	31959

Note: These values are equal to one over the impedance per foot and based upon resistance and reactance values found in IEEE Std 241-1990 (Gray Book), IEEE Recommended Practice for Electric Power Systems in Commerical Buildings & IEEE Std 242-1986 (Buff Book), IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems. Where resistance and

Point-To-Point Method Of Short-Circuit Calc

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Table 4. "M" (Multiplier)*

f	M	f	M
0.01	0.99	1.50	0.40
0.02	0.98	1.75	0.36
0.03	0.97	2.00	0.33
0.04	0.96	2.50	0.29
0.05	0.95	3.00	0.25
0.06	0.94	3.50	0.22
0.07	0.93	4.00	0.20
0.08	0.93	5.00	0.17
0.09	0.92	6.00	0.14
0.10	0.91	7.00	0.13
0.15	0.87	8.00	0.11
0.20	0.83	9.00	0.10
0.25	0.80	10.00	0.09
0.30	0.77	15.00	0.06
0.35	0.74	20.00	0.05
0.40	0.71	30.00	0.03
0.50	0.67	40.00	0.02
0.60	0.63	50.00	0.02
0.70	0.59	60.00	0.02
0.80	0.55	70.00	0.01
0.90	0.53	80.00	0.01
1.00	0.50	90.00	0.01
1.20	0.45	100.00	0.01

$$* \; M = \frac{1}{1 + f}$$

Table 5. Short-Circuit Currents Available from Various Size Transformers

(Based upon actual field nameplate data, published information, or from utility transformer worst case impedance)

Voltage and Phase	KVA	Full Load Amps	% Impedance†† (nameplate)	Short Circuit Amps†
120/240 1 ph.*	25	104	1.5	12175
	37.5	156	1.5	18018
	50	208	1.5	23706
	75	313	1.5	34639
	100	417	1.6	42472
	167	696	1.6	66644
120/208 3 ph.**	45	125	1.0	13879
	75	208	1.0	23132
	112.5	312	1.11	31259
	150	416	1.07	43237
	225	625	1.12	61960
	300	833	1.11	83357
	500	1388	1.24	124364
	750	2082	3.50	66091
	1000	2776	3.50	88121
	1500	4164	3.50	132181
	2000	5552	4.00	154211
	2500	6940	4.00	192764
277/480 3 ph.**	75	90	1.0	10035
	112.5	135	1.0	15053
	150	181	1.20	16726
	225	271	1.20	25088
	300	361	1.20	33451
	500	602	1.30	51463
	750	903	3.50	28672
	1000	1204	3.50	38230
	1500	1806	3.50	57345
	2000	2408	4.00	66902
	2500	3011	4.00	83628

Table 5 Notes:

* Single phase values are L-N values at transformer terminals. These figures are based on change in turns ratio between primary and secondary, 100,000 KVA primary, zero feet from terminals of transformer, 1.2 (%X) and 1.5 (%R) multipliers for L-N vs. L-L reactance and resistance values and transformer X/R ratio = 3.

** Three-phase short-circuit currents based on "infinite" primary.

†† UL listed transformers 25 KVA or greater have a ±10% impedance tolerance. Transformers constructed to ANSI standards have a ± 7.5% impedance tolerance (two-winding construction). Short-circuit amps reflect a "worst case" condition (-10%).

† Fluctuations in system voltage will affect the available short-circuit current. For example, a 10% increase in system voltage will result in a 10% increase in the available short-circuit currents shown in the table.

Aluminum AWG or kcmil	Three Single Conductors Conduit Steel 600V	5kV	15kV	Nonmagnetic 600V	5kV	15kV	Three-Conductor Cable Conduit Steel 600V	5kV	15kV	Nonmagnetic 600V	5kV	15kV
14	237	-	-	237	-	-	237	-	-	237	-	-
12	376	-	-	376	-	-	376	-	-	376	-	-
10	599	-	-	599	-	-	599	-	-	599	-	-
8	951	950	-	952	951	-	952	951	-	952	952	-
6	1481	1476	1472	1482	1479	1476	1482	1480	1478	1482	1481	1479
4	2346	2333	2319	2350	2342	2333	2351	2347	2339	2353	2350	2344
3	2952	2928	2904	2961	2945	2929	2963	2955	2941	2966	2959	2949
2	3713	3670	3626	3730	3702	3673	3734	3719	3693	3740	3725	3709
1	4645	4575	4498	4678	4632	4580	4686	4664	4618	4699	4682	4646
1/0	5777	5670	5493	5838	5766	5646	5852	5820	5717	5876	5852	5771
2/0	7187	6968	6733	7301	7153	6986	7327	7271	7109	7373	7329	7202
3/0	8826	8467	8163	9110	8851	8627	9077	8981	8751	9243	9164	8977
4/0	10741	10167	9700	11174	10749	10387	11185	11022	10642	11409	11277	10969
250	12122	11460	10849	12862	12343	11847	12797	12636	12115	13236	13106	12661
300	13910	13009	12193	14923	14183	13492	14917	14698	13973	15495	15300	14659
350	15484	14280	13288	16813	15858	14955	16795	16490	15541	17635	17352	16501
400	16671	15355	14188	18506	17321	16234	18462	18064	16921	19588	19244	18154
500	18756	16828	15657	21391	19503	18315	21395	20607	19314	23018	22381	20978
600	20093	18428	16484	23451	21718	19635	23633	23196	21349	25708	25244	23295
750	21766	19685	17686	25976	23702	21437	26432	25790	23750	29036	28262	25976
1,000	23478	21235	19006	28779	26109	23482	29865	29049	26608	32938	31920	29135

reactance values differ or are not available, the Buff Book values have been used. The values for reactance in determining the C Value at 5 KV & 15 KV are from the Gray Book only (Values for 14-10 AWG at 5 kV and 14-8 AWG at 15 kV are not available and values for 3 AWG have been approximated).

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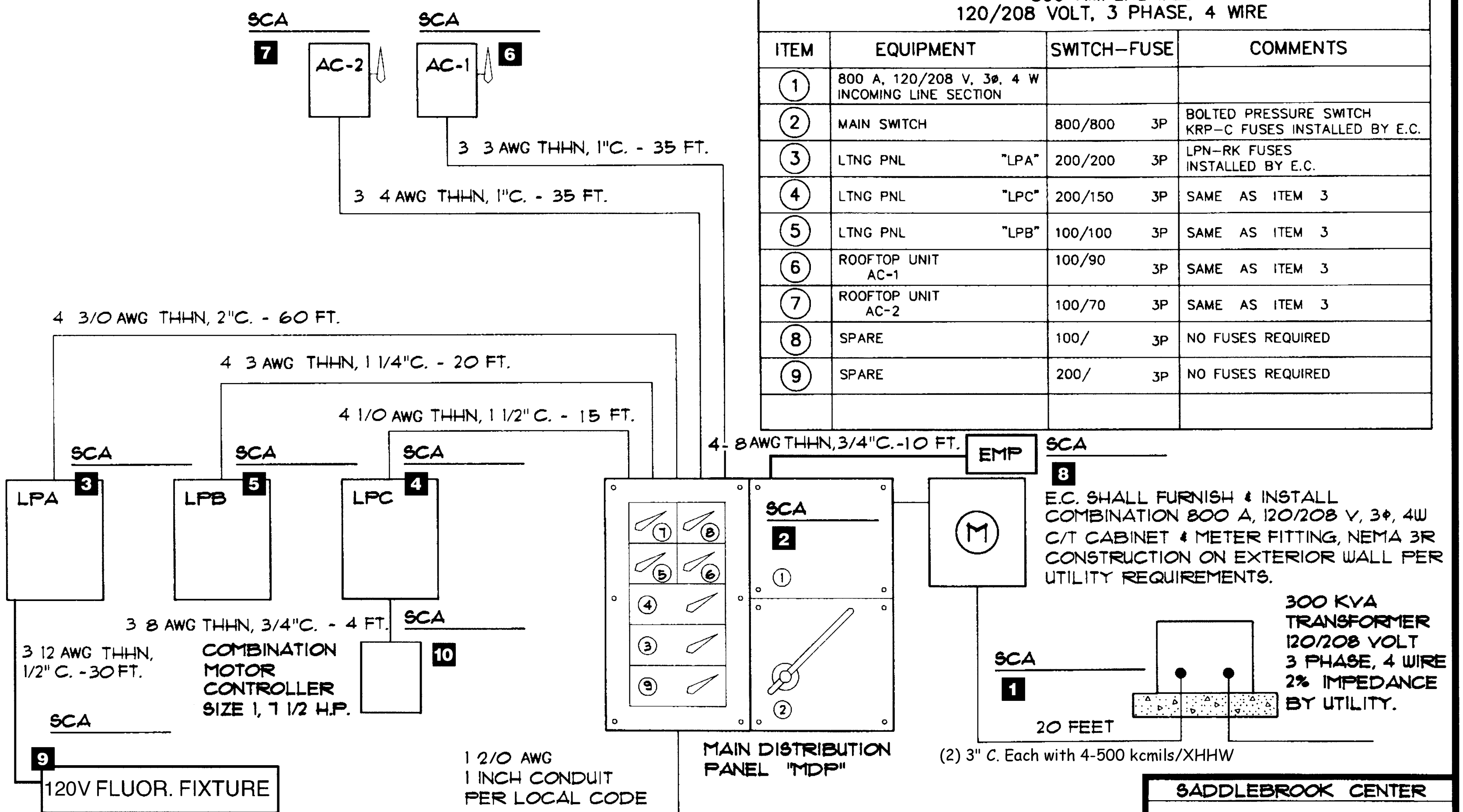
MAIN DISTRIBUTION PANEL "MDP"

800 AMPERE MLO
120/208 VOLT, 3 PHASE, 4 WIRE

ITEM	EQUIPMENT	SWITCH–FUSE	COMMENTS
1	800 A, 120/208 V, 3Φ, 4 W INCOMING LINE SECTION		
2	MAIN SWITCH	800/800 3P	BOLTED PRESSURE SWITCH KRP–C FUSES INSTALLED BY E.C.
3	LTNG PNL "LPA"	200/200 3P	LPN–RK FUSES INSTALLED BY E.C.
4	LTNG PNL "LPC"	200/150 3P	SAME AS ITEM 3
5	LTNG PNL "LPB"	100/100 3P	SAME AS ITEM 3
6	ROOFTOP UNIT AC-1	100/90 3P	SAME AS ITEM 3
7	ROOFTOP UNIT AC-2	100/70 3P	SAME AS ITEM 3
8	SPARE	100/ 3P	NO FUSES REQUIRED
9	SPARE	200/ 3P	NO FUSES REQUIRED



NOTE: SHORT CIRCUIT AMPERES (SCA) IN RMS VALUES UNLESS OTHERWISE NOTED.

NOTE: ALL CONDUCTORS COPPER IN STEEL RACEWAY.

NOTE: FLUORESCENT FIXTURES INCLUDE HLR HOLDERS WITH GLR-2 FUSES.

SADDLEBROOK CENTER	
SCALE: NTS	APPROVED BY: RCM
DATE:	DRAWN BY: RCM
DRAWING NUMBER:	

Work Sheet Problem—Main Distribution Pa

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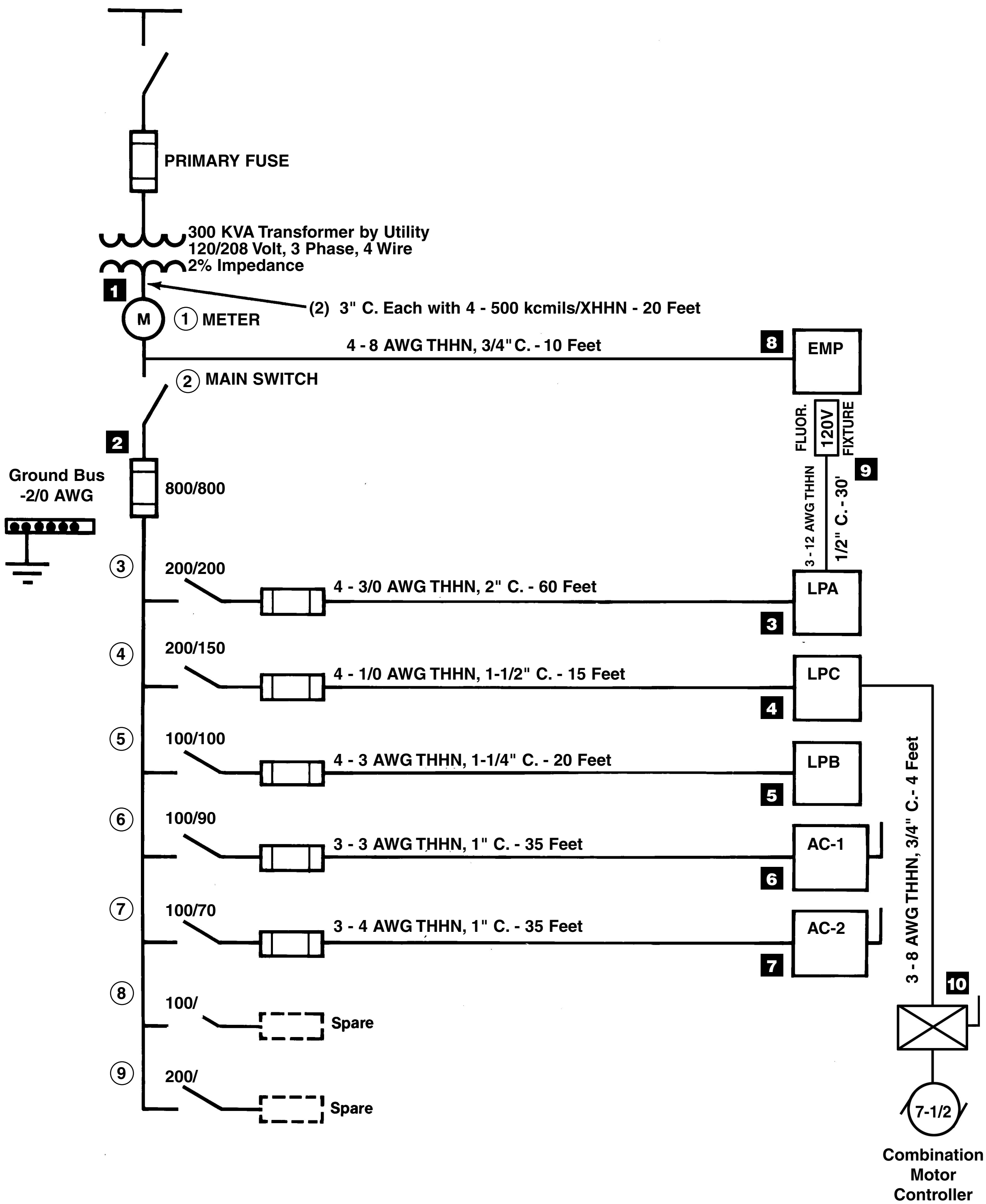

Note: Assume steel conduit.

Short-Circuit Calculations - Worksheet

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(1) Transformer (Secondary Terminals – Assuming Infinite Primary*)*

<u>Find</u>: Transformer Full-Load Amperes - I_{FLA} (3 Phase):

I_{FLA} =

<u>Find</u>: Multiplier – "M"

M =

<u>Calculate</u>: Short-Circuit Current (SCA)

SCA =

SCA $_{\text{with voltage variance}}$ =

Motor Contribution* =

* Note: Calculate additional motor short-circuit contribution. Assume 50% (400A) of the total load is from all motors. Multiply total motor FLA by 4 (400 x 4 = 1,600A). In theory, the additional motor short-circuit contribution should be calculated at all points in the system, and may vary depending upon the location.

SCA $_{\text{with voltage variance and motor contribution}}$ =

(2) MDP

Short-Circuit Current at beginning of run (Transformer Secondary Terminals with voltage variance) = ______________________

<u>Find</u>: "f" factor

f =

<u>Find</u>: Multiplier - "M"

M =

<u>Calculate</u>: Short-Circuit Current (SCA)

SCA $_{\text{with voltage variance}}$ =

Motor Contribution =

SCA $_{\text{with voltage variance and motor contribution}}$ =

(3) LPA

Short-Circuit Current at beginning of run (MDP with voltage variance) = ________________

<u>Find</u>: "f" factor

f =

<u>Find</u>: Multiplier - "M"

M =

<u>Calculate</u>: Short-Circuit Current (SCA)

SCA $_{\text{with voltage variance}}$ =

Motor Contribution =

SCA $_{\text{with voltage variance and motor contribution}}$ =

(4) LPC

Short-Circuit Current at beginning of run (MDP with voltage variance) = ________________

<u>Find</u>: "f" factor

f =

<u>Find</u>: Multiplier - "M"

M =

<u>Calculate</u>: Short-Circuit Current (SCA)

SCA $_{\text{with voltage variance}}$ =

Motor Contribution =

SCA $_{\text{with voltage variance and motor contribution}}$ =

Short-Circuit Calculations - Worksheet

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(5) LPB

Short-Circuit Current at beginning of run (MDP with voltage variance) = ________________

Find: "f" factor

f =

Find: Multiplier - "M"

M =

Calculate: Short-Circuit Current (SCA)

$SCA_{\text{with voltage variance}}$ =

Motor Contribution =

$SCA_{\text{with voltage variance and motor contribution}}$ =

(6) AC-1

Short-Circuit Current at beginning of run (MDP with voltage variance) = ________________

Find: "f" factor

f =

Find: Multiplier - "M"

M =

Calculate: Short-Circuit Current (SCA)

$SCA_{\text{with voltage variance}}$ =

Motor Contribution =

$SCA_{\text{with voltage variance and motor contribution}}$ =

(7) AC-2

Short-Circuit Current at beginning of run (MDP with voltage variance) = ________________

Find: "f" factor

f =

Find: Multiplier - "M"

M =

Calculate: Short-Circuit Current (SCA)

$SCA_{\text{with voltage variance}}$ =

Motor Contribution =

$SCA_{\text{with voltage variance and motor contribution}}$ =

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(8) EMP

Short-Circuit Current at beginning of run (MDP with voltage variance) = ________________

Find: "f" factor

f =

Find: Multiplier - "M"

M =

Calculate: Short-Circuit Current (SCA)

$SCA_{\text{with voltage variance}}$ =

Motor Contribution =

$SCA_{\text{with voltage variance and motor contribution}}$ =

(9) Fluorescent Fixture

Short-Circuit Current at beginning of run (LPA with voltage variance) = ________________

Find: "f" factor

f =

Find: Multiplier - "M"

M =

Calculate: Short-Circuit Current (SCA)

$SCA_{\text{with voltage variance}}$ =

*Ignore motor contribution for this step

(10) Combination Motor Controller

Short-Circuit Current at beginning of run (LPC with voltage variance) = ________________

Find: "f" factor

f =

Find: Multiplier - "M"

M =

Calculate: Short-Circuit Current (SCA)

$SCA_{\text{with voltage variance}}$ =

Motor Contribution =

$SCA_{\text{with voltage variance and motor contribution}}$ =