ECET 4520

Industrial Distribution Systems, Illumination, and the NEC

Short Circuit Calculations

Overcurrent Protection

110.9 – Interrupting Rating

Equipment intended to interrupt current at fault levels shall have an interrupting rating sufficient for the nominal circuit voltage and the current that is available at the line terminals of the equipment.

Equipment intended to interrupt current at other than fault levels shall have an interrupting rating at nominal circuit voltage sufficient for the current that must be interrupted.

Overcurrent Protection

<u>Overcurrent protection</u> for conductors is provided in order to open the circuit if the current reaches a value that will cause a dangerous temperature in the circuit conductors, conductor insulation, or attached devices.

The NEC provides many guidelines relating to the protection of electrical distribution systems and to the selection of overcurrent protection devices.

Of interest are the guidelines relating to the ratings of any overcurrent protection device used in a system.

Overcurrent Protection

Protection is provided by an overcurrent device, connected in series with each circuit conductor, that has a rating (or setting) that is not higher than the allowable ampacity of the conductor.

– NEC 230.90(A)

Overcurrent protection shall be provided in each ungrounded circuit conductor and shall be located at the point where the conductors receive their supply.

– NEC 240.21

Interrupting Rating of Equipment

Equipment intended to interrupt current at fault levels shall have an interrupting rating sufficient for the nominal circuit voltage and the current that is available (if the fault occurs) at the line terminals of the equipment.

– NEC 110.9

<u>Interrupting Rating</u> – The highest current at rated voltage that a device is intended to interrupt under standard test conditions.

– NEC 100

Interrupting Rating of Equipment

Determined under standard conditions, the "interrupt rating" specifies the maximum amount of current a protective device can cut off safely ... i.e. without harm to personnel or resulting damage to equipment, the premises or the device itself.

For example, a circuit breaker trips "safely“ if it successfully interrupts the fault, can be reset afterwards, and continues to function properly.

– “Protecting the Electrical Distribution System…” Engineers Newsletter 1998 Vol.27 No.3 by Guckelberger
http://www.trane.com/commercial/library/vol273/

Interrupting Rating of Equipment

Short-circuit current is often two orders of magnitude (100x) greater than normal or rated operating current.

If a circuit breaker or fuse fails to successfully interrupts the fault, this enormous amperage can rapidly heat components to a very high temperature that can destroy the insulation, melt metal, start fires ... and even cause an explosion if arcing occurs.

– "Protecting the Electrical Distribution System…" Engineers Newsletter 1998 Vol.27 No.3 by Guckelberger
http://www.trane.com/commercial/library/vol273/

Interrupting Rating of Equipment

Proper selection of an overcurrent protection device, in terms of its Interrupting Rating, requires knowledge of the maximum short-circuit current that the device is expected to interrupt.

The magnitude of this short-circuit current is dependent on the design of the system and the location of the device within the system, and thus must be calculated for each location.

Short-Circuit Calculations

In a three-phase (3Φ) distribution system, the largest currents typically result from a fault during which all three phases short-circuit together. We will refer to this type of fault as a line-line-line (L-L-L) fault.

Currents due to line-neutral or other types of faults can be estimated from the L-L-L fault current (if it is known).

There are several standardized methods available to calculate the available short-circuit (SC) current, one of which is the Point-to-Point Method of fault current calculation.

Point-to-Point SC Calculations

The Point-to-Point (P-t-P) method of fault current calculation will be outlined in the following slides, as presented by Cooper Bussmann in:

"A Simple Approach to Short Circuit Calculations" Engineering Dependable Protection - Part I, Bulletin EDP-1, 2004

- http://www1.cooperbussmann.com/library/docs/EDP-1.pdf

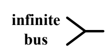
The PtP method utilizes a step-by-step process that starts at the service entrance of an electrical system and works inwards towards the end-use outlets.

Point-to-Point SC Calculations

<u>The Point-to-Point Method</u>

- To begin, the available short-circuit current is determined or calculated for the 1st point in the system.
- The current magnitude at the 1st point is then applied in order to calculate the available current at the next point in the system.
- The process is continued until the fault current is known at all required points in the system.

P-to-P Method Basic Components

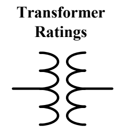


"Infinite Bus"

The point of connection from the utility is often assumed to be an "infinite bus", implying that it is able to provide infinite current at rated voltage.

With the infinite bus assumption, the utility connection can be modeled as an ideal voltage source with zero output impedance.

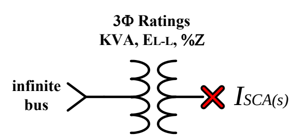
P-to-P Method Basic Components



Transformers

Transformers are used within distribution systems to step-up or step-down the operational voltage as required based on the design of the system.

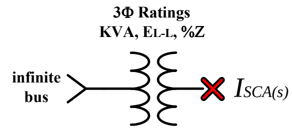
P-to-P Method Basic Components



Transformer Connected to an "Infinite Bus"

When a transformer is connected to an infinite bus, the primary factor that limits the SC current available at the secondary terminals is the transformer's series-equivalent impedance.

P-to-P Method Basic Components



Transformer Connected to an “Infinite Bus”

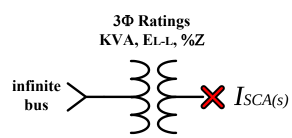
The transformer’s ratings provide the information required for this calculation:

KVA – Apparent Power |S|

$E_{L\text{-}L}$ – Secondary Line Voltage

%Z – Percent Series Impedance

P-to-P Method Basic Components

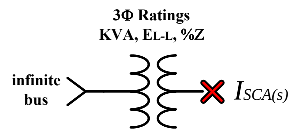


Transformer Connected to an “Infinite Bus”

Step 1 – Determine the rated current, $I_{FLA(s)}$ (full-load amps), for the secondary winding of the transformer:

$$I_{FLA(s)} = \frac{|S_{rated}|}{\sqrt{3}\cdot V_{line}} = \frac{\text{KVA x 1000}}{\sqrt{3}\cdot \text{E}_{\text{L-L}}}$$

P-to-P Method Basic Components

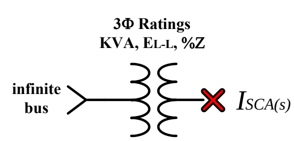


Transformer Connected to an "Infinite Bus"

Step 2 – Calculate a multiplier, M, based on the percent impedance of the transformer:

$$Multiplier = M = \frac{100\%}{\%Z}$$

P-to-P Method Basic Components

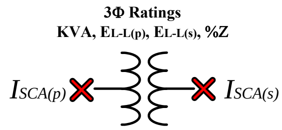


Transformer Connected to an "Infinite Bus"

Step 3 – Determine the SC current available at the secondary terminals, $I_{SCA(s)}$, by applying the multiplier to the rated secondary current $I_{FLA(s)}$:

$$I_{SCA(s)} = I_{FLA(s)} \cdot M$$

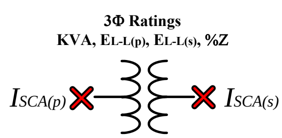
P-to-P Method Basic Components



Transformer with Limited Primary Current

Transformers are often connected to <u>other than</u> an infinite bus such that there is a limited SC current, $I_{SCA(p)}$, available at the primary terminals.

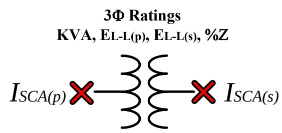
P-to-P Method Basic Components



Transformer with Limited Primary Current

This is similar in nature to the transformer being supplied by a practical voltage source that includes an ideal source in series with an (output) impedance that limits the source current under SC conditions.

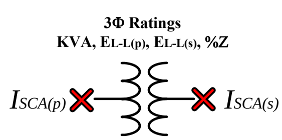
P-to-P Method Basic Components



Transformer with Limited Primary Current

When this occurs, the SC current available at the primary terminals must be taken into account when solving for the SC current available at the secondary terminals, $I_{SCA(s)}$.

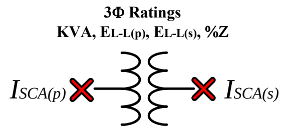
P-to-P Method Basic Components



Transformer with Limited Primary Current

In addition to the rated KVA and %Z of the transformer, both the rated primary and secondary voltages must be known in order to perform this calculation.

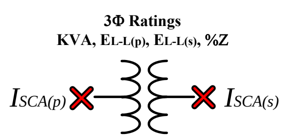
P-to-P Method Basic Components



Transformer with Limited Primary Current

The following procedure is used to determine the SC current available at the secondary terminals of a transformer whose primary winding is supplied by a source that provides a limited SC current…

P-to-P Method Basic Components

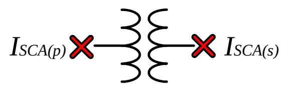


Transformer with Limited Primary Current

Step 1 – Determine an *f*-factor that provides a ratio of impedance of the source supplying the transformer over the impedance of the transformer.

P-to-P Method Basic Components

3Φ Ratings
KVA, $E_{L-L(p)}$, $E_{L-L(s)}$, %Z



Transformer with Limited Primary Current

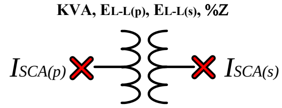
Step 1 – The *f*-factor for the transformer is determined from:

$$f = \frac{\sqrt{3} \cdot I_{SCA(p)} \cdot E_{L-L(p)} \cdot \%Z}{100{,}000 \cdot KVA}$$

$I_{SCA(p)}$ is the available SC current at the primary terminals,
$E_{L-L(p)}$ is the rated (operational) primary line voltage,
%Z is the transformer's percent series impedance, and
KVA is the transformer's rated apparent power.

P-to-P Method Basic Components

3Φ Ratings
KVA, $E_{L-L(p)}$, $E_{L-L(s)}$, %Z

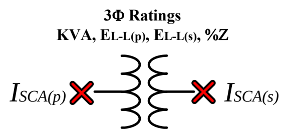


Transformer with Limited Primary Current

Step 2 – Calculate a multiplier, M, based on the *f*-factor for the transformer:

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

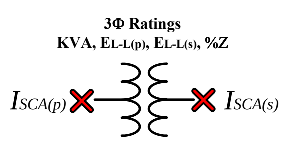
P-to-P Method Basic Components



Transformer with Limited Primary Current

Step 2 – The multiplier, M, is used to adjust the available SC current by combining the transformer impedance in series with the source impedance, thus increasing the overall system impedance and decreasing the available SC current.

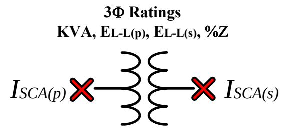
P-to-P Method Basic Components



Transformer with Limited Primary Current

Step 2 – Note that, when using the multiplier M, only the impedance magnitudes are considered. This may add some error into the results, but generally the error is minimal.

P-to-P Method Basic Components

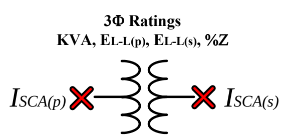


Transformer with Limited Primary Current

Step 3 – Determine the SC current available at the secondary terminals, $I_{SCA(s)}$, by applying the multiplier to $I_{SCA(p)}$:

$$I_{SCA(s)} = I_{SCA(p)} \cdot M \cdot \frac{V_{pri}}{V_{\sec}} = I_{SCA(p)} \cdot M \cdot \frac{E_{L-L(p)}}{E_{L-L(s)}}$$

P-to-P Method Basic Components



Transformer with Limited Primary Current

Step 3 – Note that the turns-ratio of the transformer is included when calculating the available SC current.

$$I_{SCA(s)} = I_{SCA(p)} \cdot M \cdot \frac{E_{L-L(p)}}{E_{L-L(s)}}$$

P-to-P Method Basic Components

# of Conductors
Conductor Size (AWG/kcmil)
Conductor Material (Cu/Al)
Conductor Length (ft)
Conductor Location

Feeders or Branch Circuits

Feeders and branch circuits are the basic building blocks of a distribution system. They are composed of a set of conductors and are used to carry current from one point in the system to another.

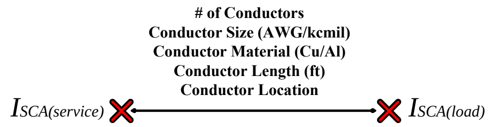
P-to-P Method Basic Components

# of Conductors
Conductor Size (AWG/kcmil)
Conductor Material (Cu/Al)
Conductor Length (ft)
Conductor Location

Feeders or Branch Circuits

Although ideally small compared to the impedance of the loads that they are serving, the impedance of the conductors provides a limit to the current that will flow through them under SC conditions.

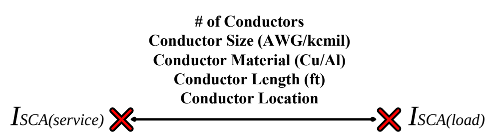
P-to-P Method Basic Components



Feeders or Branch Circuits

Typically feeders or branch circuits are connected such that there is a limited amount of SC current available at their "service" end due to the impedance of the other system components connecting them to the service.

P-to-P Method Basic Components



Feeders or Branch Circuits

The following procedure is used to determine the SC current available at the load-end of a feeder or branch circuit whose service-end is supplied by a source that provides a limited SC current, $I_{SCA(service)}$…

P-to-P Method Basic Components

# of Conductors
Conductor Size (AWG/kcmil)
Conductor Material (Cu/Al)
Conductor Length (ft)
Conductor Location

$I_{SCA(service)}$ ✕ ⟷ ✕ $I_{SCA(load)}$

Feeders or Branch Circuits

Step 1 – Determine the *f*-factor for the conductors:

$$f = \frac{\sqrt{3} \cdot L \cdot I_{L-L-L}}{c \cdot n \cdot V_{line}}$$

I_{L-L-L} is the available SC current at the service-end of the feeder,
L is the length of the feeder,
c is the ft/Ω value for the conductors (see lookup table*), and
n is the number of parallel conductors in each phase.y

P-to-P Method Basic Components

# of Conductors
Conductor Size (AWG/kcmil)
Conductor Material (Cu/Al)
Conductor Length (ft)
Conductor Location

$I_{SCA(service)}$ ✕ ⟷ ✕ $I_{SCA(load)}$

Feeders or Branch Circuits

Step 1 – The “c” value within the *f*-factor formula is relates to the electrical characteristics of the conductors and is found by choosing the conductor size and type in a look-up table.

P-to-P Method Basic Components

"C" Values for Conductors and Busway

Table 6. " C" Values for Conductors and Busway

Copper												
AWG or kcmil	Three Single Conductors						Three-Conductor Cable					
	Conduit						Conduit					
	Steel			Nonmagnetic			Steel			Nonmagnetic		
	600V	5KV	15KV	600V	5KV	15KV	600V	5KV	15KV	600V	5KV	15KV
14	389	389	389	389	389	389	389	389	389	389	389	389
12	617	617	617	617	617	617	617	617	617	617	617	617
10	981	981	981	981	981	981	981	981	981	981	981	981
8	1557	1551	1557	1558	1555	1558	1559	1557	1559	1559	1558	1559
6	2425	2406	2389	2430	2417	2406	2431	2424	2414	2433	2428	2420
4	3806	3750	3695	3825	3789	3752	3830	3811	3778	3837	3823	3798
3	4760	4760	4760	4802	4802	4802	4760	4790	4760	4802	4802	4802
2	5906	5736	5574	6044	5926	5809	5989	5929	5827	6087	6022	5957
1	7292	7029	6758	7493	7306	7108	7454	7364	7188	7579	7507	7364
1/0	8924	8543	7973	9317	9033	8590	9209	9086	8707	9472	9372	9052
2/0	10755	10061	9389	11423	10877	10318	11244	11045	10500	11703	11528	11052
3/0	12843	11804	11021	13923	13048	12360	13656	13333	12613	14410	14118	13461
4/0	15082	13605	12542	16673	15351	14347	16391	15890	14813	17482	17019	16012
250	16483	14924	13643	18593	17120	15865	18310	17850	16465	19779	19352	18001
300	18176	16292	14768	20867	18975	17408	20617	20051	18318	22524	21938	20163
350	19703	17385	15678	22736	20526	18672	19557	21914	19821	22736	24126	21982
400	20565	18235	16365	24296	21786	19731	24253	23371	21042	26915	26044	23517
500	22185	19172	17492	26706	23277	21329	26980	25449	23125	30028	28712	25916
600	22965	20567	47962	28033	25203	22097	28752	27974	24896	32236	31258	27766
750	24136	21386	18888	28303	25430	22690	31050	30024	26932	32404	31338	28303
1000	25278	22539	19923	31490	28083	24887	33864	32688	29320	37197	35748	31959

- EDP-1 pg. 27 Table 6 – "C" Values for Conductors and Busway

P-to-P Method Basic Components

# of Conductors
Conductor Size (AWG/kcmil)
Conductor Material (Cu/Al)
Conductor Length (ft)
Conductor Location

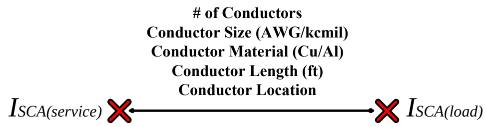
$I_{SCA(service)}$ ✕ ⟷ ✕ $I_{SCA(load)}$

Feeders or Branch Circuits

Step 2 – Calculate a multiplier, M, based on the *f*-factor for the conductors:

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

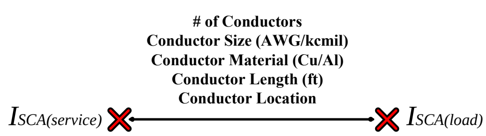
P-to-P Method Basic Components



Feeders or Branch Circuits

Step 2 – The multiplier, M, is used to adjust the available SC current by combining the conductor impedance in series with the source impedance, thus increasing the overall impedance and decreasing the available SC current.

P-to-P Method Basic Components

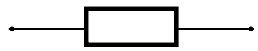


Feeders or Branch Circuits

Step 3 – Apply the multiplier to $I_{SCA(service)}$ to determine the SC current available at the load-end of the conductors, $I_{SCA(load)}$:

$$I_{SCA(load)} = I_{SCA(service)} \cdot M$$

P-to-P Method Basic Components

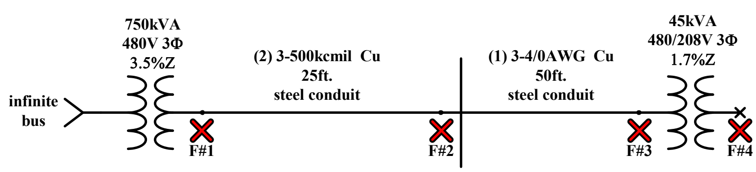


Other System Components

Other system components, such as fuses and circuit-breakers, are often ignored when applying the P-t-P method for SC current calculation due to this low impedances and negligible effect on the current magnitude.

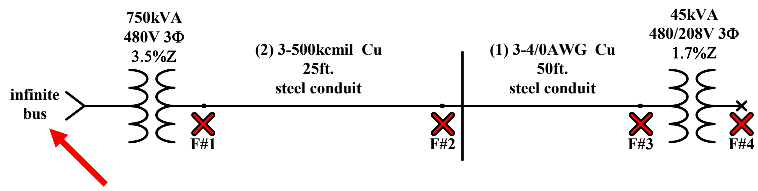
Point-to-Point Method Example

Given the following electrical system:



Determine the available line-line-line (L-L-L), SC current at each of the four specified fault locations (F#1→F#4).

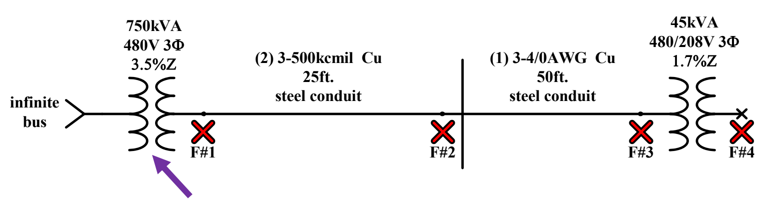
Point-to-Point Method Example



Part 1 – Determine the L-L-L SC current available from the utility.

In this case, the utility connection is assumed to be an "infinite bus" connection that is able to supply unlimited SC current.

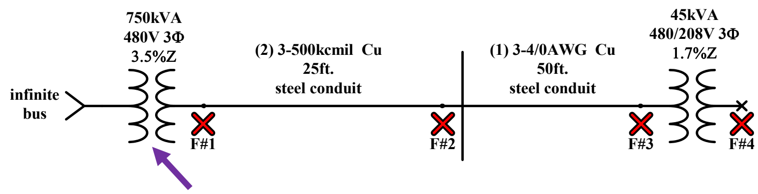
Point-to-Point Method Example



Part 2 – Determine the L-L-L SC current at the secondary terminals of the service transformer. (F#1)

In this case, the primary of the transformer is assumed to be connected to an infinite bus. The standard procedure is applied in order to determine the SC current available at the secondary terminals.

Point-to-Point Method Example



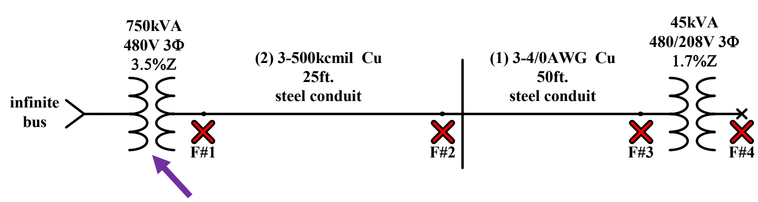
Part 2A – Determine the L-L-L SC current at the secondary terminals of the service transformer. **(F#1)**

First, determine the rated secondary full-load current, $I_{FLA(s)}$, of the transformer:

$$I_{FLA(S)} = \frac{\text{KVA x 1000}}{\sqrt{3} \cdot E_{L-L}} = \frac{750 \text{ x } 1000}{\sqrt{3} \cdot 480} = 902.1\,A$$

- EDP-1 pg. 17 "Basic Point-to-Point Calculation Procedure – Step1"

Point-to-Point Method Example



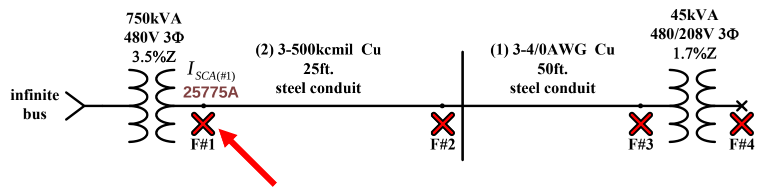
Part 2B – Determine the L-L-L SC current at the secondary terminals of the service transformer. **(F#1)**

Next, determine the multiplier, M, based on the percent impedance of the transformer:

$$Multiplier = \frac{100\%}{\%Z} = \frac{100\%}{3.5\%} = 28.57$$

- EDP-1 pg. 17 "Basic Point-to-Point Calculation Procedure – Step2"

Point-to-Point Method Example



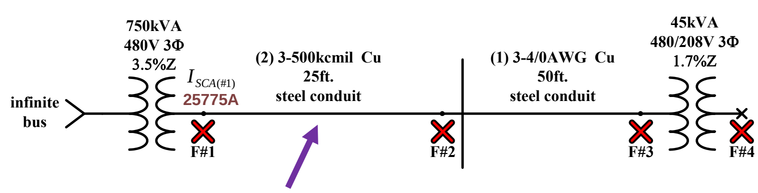
Part 2C – Determine the L-L-L SC current at the secondary terminals of the service transformer. (F#1)

Finally, determine the available L-L-L SC current at the secondary terminals by:

$$I_{SCA(\#1)} = I_{FLA(S)} \cdot Multiplier = (902.1) \cdot (28.57) = 25775\ A$$

- EDP-1 pg. 17 "Basic Point-to-Point Calculation Procedure – Step3"

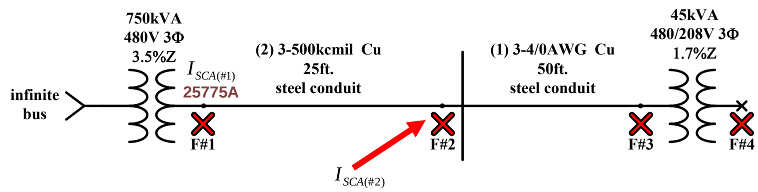
Point-to-Point Method Example



Part 3 – Determine the L-L-L SC current at the load-end of the 25' feeder. (F#2)

Note that this feeder is constructed using two (2) parallel sets of 3Φ conductors. A single set of larger conductors could have been utilized, but smaller conductors were chosen because they are easier to work with.

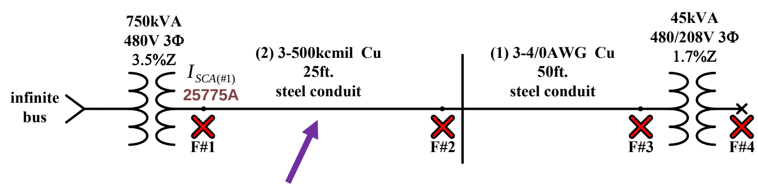
Point-to-Point Method Example



Part 3 – Determine the L-L-L SC current at the load-end of the 25' feeder. (F#2)

The SC current available at the load-end of the feeder, $I_{SCA(\#2)}$, may be determined from the available SC current at the service-end of the feeder, $I_{SCA(\#1)}$.

Point-to-Point Method Example



Part 3A – Determine the L-L-L SC current at the load-end of the 25' feeder. (F#2)

First, determine the *f*-factor for the feeder:

$$f = \frac{\sqrt{3} \cdot L \cdot I_{L-L-L}}{c \cdot n \cdot V_{line}} = \frac{\sqrt{3} \cdot (25) \cdot (25775)}{(22185) \cdot (2) \cdot (480)} = 0.0524$$

- EDP-1 pg. 17 "Basic Point-to-Point Calculation Procedure – Step4"

Point-to-Point Method Example

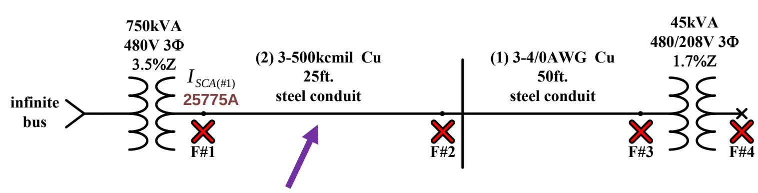
"C" Values for Conductors and Busway

Table 6. " C" Values for Conductors and Busway

Copper												
AWG or kcmil	Three Single Conductors						Three-Conductor Cable					
	Conduit						Conduit					
	Steel			Nonmagnetic			Steel			Nonmagnetic		
	600V	5KV	15KV	600V	5KV	15KV	600V	5KV	15KV	600V	5KV	15KV
14	389	389	389	389	389	389	389	389	389	389	389	389
12	617	617	617	617	617	617	617	617	617	617	617	617
10	981	981	981	981	981	981	981	981	981	981	981	981
8	1557	1551	1557	1558	1555	1558	1559	1557	1559	1559	1558	1559
6	2425	2406	2389	2430	2417	2406	2431	2424	2414	2433	2428	2420
4	3806	3750	3695	3825	3789	3752	3830	3811	3778	3837	3823	3798
3	4760	4760	4760	4802	4802	4802	4760	4790	4760	4802	4802	4802
2	5906	5736	5574	6044	5926	5809	5989	5929	5827	6087	6022	5957
1	7292	7029	6758	7493	7306	7108	7454	7364	7188	7579	7507	7364
1/0	8924	8543	7973	9317	9033	8590	9209	9086	8707	9472	9372	9052
2/0	10755	10061	9389	11423	10877	10318	11244	11045	10500	11703	11528	11052
3/0	12843	11804	11021	13923	13048	12360	13656	13333	12613	14410	14118	13461
4/0	15082	13605	12542	16673	15351	14347	16391	15890	14813	17482	17019	16012
250	16483	14924	13643	18593	17120	15865	18310	17850	16465	19779	19352	18001
300	18176	16292	14768	20867	18975	17408	20617	20051	18318	22524	21938	20163
350	19703	17385	15678	22736	20526	18672	19557	21914	19821	22736	24126	21982
400	20565	18235	16365	24296	21786	19731	24253	23371	21042	26915	26044	23517
500	22185	19172	17492	26706	23277	21329	26980	25449	23125	30028	28712	25916
600	22965	20567	47962	28033	25203	22097	28752	27974	24896	32236	31258	27766
750	24136	21386	18888	28303	25430	22690	31050	30024	26932	32404	31338	28303
1000	25278	22539	19923	31490	28083	24887	33864	32688	29320	37197	35748	31959

- EDP-1 pg. 27 Table 6 – "C" Values for Conductors and Busway

Point-to-Point Method Example



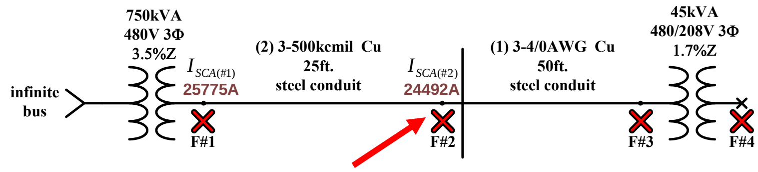
Part 3B – Determine the L-L-L SC current at the load-end of the 25' feeder. **(F#2)**

Next, determine the *multiplier M*:

$$M = \frac{1}{1+f} = \frac{1}{1+(0.0524)} = 0.9502$$

- EDP-1 pg. 17 "Basic Point-to-Point Calculation Procedure – Step5"

Point-to-Point Method Example



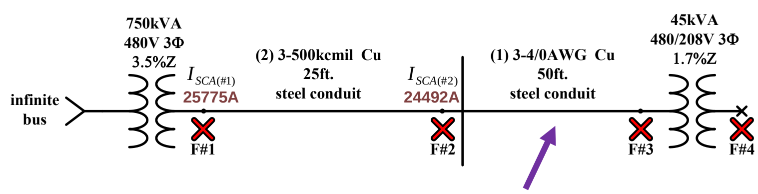
Part 3C – Determine the L-L-L SC current at the load-end of the 25' feeder. (F#2)

Then, determine the L-L-L SC current at the load-end of the 25' feeder:

$$I_{SCA(\#2)} = I_{SCA(\#1)} \cdot M = (25775)\cdot(0.9502) = 24492\ A$$

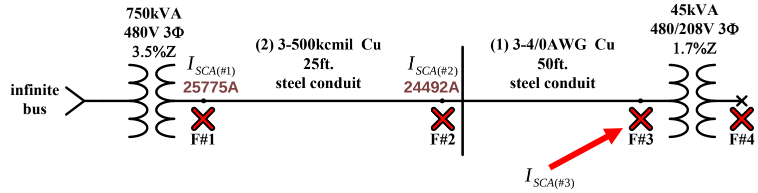
- EDP-1 pg. 17 "Basic Point-to-Point Calculation Procedure – Step6"

Point-to-Point Method Example



Part 4 – Determine the L-L-L SC current at the load-end of the 50' feeder section. (F#3)

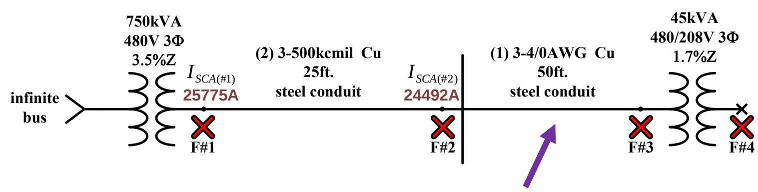
Point-to-Point Method Example



Part 4 – **Determine the L-L-L SC current at the load-end of the 50' feeder section. (F#3)**

The available SC current, $I_{SCA(\#3)}$, at the load-end of the 50' feeder section of conductors may be determined using the exact same procedure as that for the 25' section.

Point-to-Point Method Example



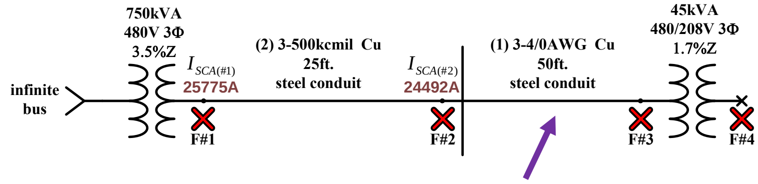
Part 4 – **Determine the L-L-L SC current at the load-end of the 50' feeder section. (F#3)**

The *f*-factor for the 50' feeder is:

$$f = \frac{\sqrt{3} \cdot L \cdot I_{L-L-L}}{c \cdot n \cdot V_{line}} = \frac{\sqrt{3} \cdot (50) \cdot (24492)}{(15082) \cdot (1) \cdot (480)} = 0.293$$

- EDP-1 pg. 17 "Basic Point-to-Point Calculation Procedure – Step4"

Point-to-Point Method Example



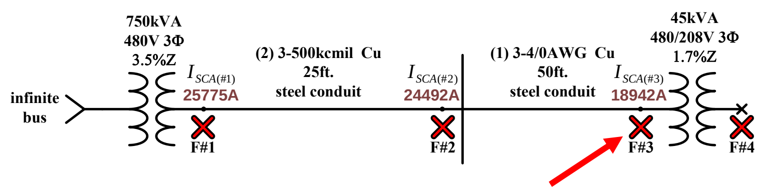
Part 4 – Determine the L-L-L SC current at the load-end of the 50' feeder section. (F#3)

The multiplier M for the 50' feeder is:

$$M = \frac{1}{1+f} = \frac{1}{1+(0.293)} = 0.7734$$

- EDP-1 pg. 17 "Basic Point-to-Point Calculation Procedure – Step5"

Point-to-Point Method Example



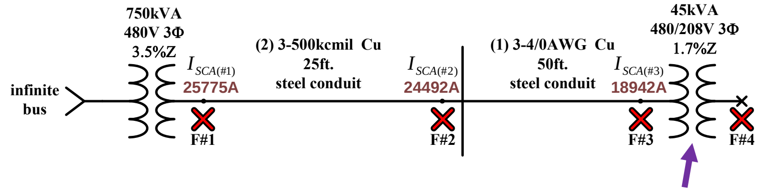
Part 4 – Determine the L-L-L SC current at the load-end of the 50' feeder section. (F#3)

The SC current at the load-end of the 50' feeder section is:

$$I_{SCA(\#3)} = I_{SCA(\#2)} \cdot M = (24492) \cdot (0.7734) = 18942\,A$$

- EDP-1 pg. 17 "Basic Point-to-Point Calculation Procedure – Step6"

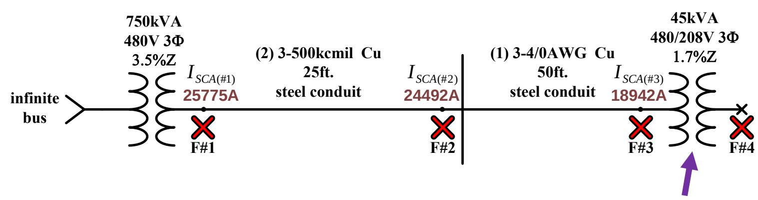
Point-to-Point Method Example



Part 5 – Determine the L-L-L SC current at the secondary terminals of the 2nd transformer. (F#4)

In this case, there is <u>limited</u> SC current available at the primary terminals of the transformer. The standard procedure is applied in order to determine the SC current available at the secondary terminals.

Point-to-Point Method Example



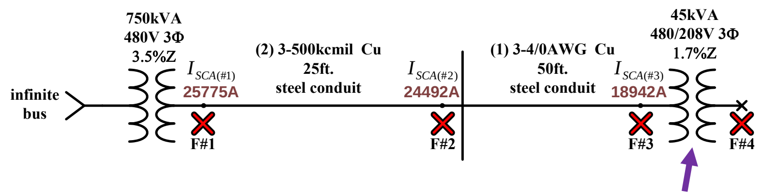
Part 5 – Determine the L-L-L SC current at the secondary terminals of the 2nd transformer. (F#4)

The *f*-factor for the 2nd transformer is:

$$f = \frac{\sqrt{3} \cdot I_{SCA(pri)} \cdot V_{pri} \cdot \%Z}{100{,}000 \cdot kVA} = \frac{\sqrt{3} \cdot (18942) \cdot (480) \cdot (1.7)}{(100{,}000) \cdot (45)} = 5.949$$

- EDP-1 pg. 17 "Procedure for Second Transformer in System – Step1"

Point-to-Point Method Example



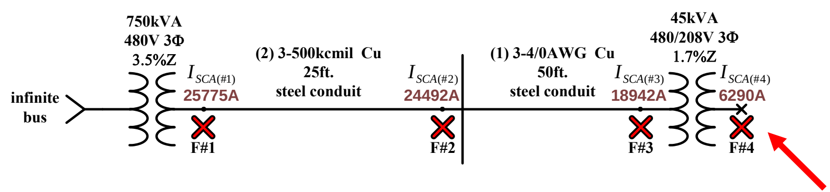
Part 5 – Determine the L-L-L SC current at the secondary terminals of the 2nd transformer. (F#4)

The multiplier M for the 2nd transformer is:

$$M = \frac{1}{1+f} = \frac{1}{1+(5.949)} = 0.1439$$

- EDP-1 pg. 17 "Procedure for Second Transformer in System – Step2"

Point-to-Point Method Example



Part 5 – Determine the L-L-L SC current at the secondary terminals of the 2nd transformer. (F#4)

The SC current at the secondary of the 2nd transformer is:

$$I_{SCA(\#4)} = I_{SCA(\#3)} \cdot M \cdot \frac{V_{pri}}{V_{\sec}} = (18942)\cdot(0.1439)\cdot\left(\frac{480}{208}\right) = 6290\,A$$

- EDP-1 pg. 17 "Procedure for Second Transformer in System – Step3"