Application Techniques

Original Instructions

Short-circuit Current Ratings and Your Industrial Control Panel

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Summary of Changes

This publication contains the following new or updated information. This list includes substantive updates only and is not intended to reflect all changes.

Topic	Page
Corrected definition of feeder circuit	4
Reformatted	throughout

Introduction

Information in this document is based on UL 508A Standard for Safety Industrial Control Panels, Third Edition, Dated April 24, 2018 and NFPA-70 NEC (National Electrical Code) 2017. NEC Article 409 requires panels to be marked with a short-circuit current rating (SCCR). In an informational note, Article 409 references UL 508A, specifically Supplement SB4, as an approved method of calculating the SCCR of a panel. Article 409 also states that an industrial control panel that contains only control circuit components does not need an SCCR rating.

The purpose of this document is to provide examples for short-circuit current ratings of panels based on the methods stated in UL 508A Supplement B. While other standards require short-circuit ratings, this document focuses on UL 508A SB4 and SB5, short circuit and panel marking. Please note that this document is an interpretation of the standard, which is the only source of the guidelines and rules that you must follow. Descriptions of the standards and requirements are brief and not binding.

Both the actual NEC and UL 508A publications contain detailed guidelines and must be adhered to. This document does not replace the code and the standards.

A UL inspector and/or Authority Having Jurisdiction (AHJ) has the final ruling on code interpretation. The definition for the AHJ can be found in NEC Article 90.4 (Enforcement).

IMPORTANT	The examples and diagrams in this publication are included solely for illustrative purposes. Because of the many variables and requirements associated with any particular installation, Rockwell Automation, Inc. cannot assume responsibility or liability for actual use based on the examples and diagrams. No patent liability is assumed by Rockwell Automation, Inc. with respect to use of information, circuits, equipment, or software described in this publication.

Terminology

The abbreviations used in the wiring examples in this document are as follows:

- CB—circuit breaker
- CONT—contactor
- HMI—human-machine interface
- OL—overload relay
- MFG—manufacturing
- MPCB—motor protection circuit breaker
- MTR—motor
- PDB—power distribution block
- PLC—programmable logic controller
- PS—power supply
- VFD—variable-frequency drive

Recent Changes to Applicable Codes and Standards

This section provides information about some of the recent changes to the 2017 version of the NEC.

Because industrial control panels are required to have SCCR ratings that meet or exceed the available fault current, it is important to know what the fault current values are. The fault current information is used to properly size the feeder and the branch circuit protective device (BCPD).

Changes to the 2017 version of the NEC

Article 409 of the NEC covers installation of industrial control panels at and under 1000 volts. This article previously applied to installations up to 600 volts. The scope of UL 508A 3rd addition, 2018, Chapter 1.1. also reflects this change.

Previously, 110.24 addressed the standard for field marking the documented date of the fault current calculation on service equipment. Article 409.22 has added guidelines to document the available fault current that feeds the control panel and the date of the calculation. The control panel needs to be able to handle the available fault current. Article 409.22 also references 409.110(4), which requires that the SCCR is listed on the panel label. Article 409.110(4) also states the SCCR can be established using an approved method, such as UL 508A

Article 670.5 (1) changed the term from fault current to short-circuit current. This change occurs in other articles, such as 409.22. Article 670.5(2) also added the requirement to field mark a panel to include the date the short-circuit current calculation was performed. The label also lists the maximum available fault current.

Changes to UL 508A, 3rd Edition

In addition to the expanded scope defined in UL508A, Chapter 1.1 that was already mentioned, there are several other changes that you should be aware of.

Chapter 2.10 Combination Motor Controller: even though this chapter is not new to the standard, Chapter 2.10 is specified throughout UL508A when it comes to short-circuit ratings. A combination motor controller has a disconnecting means, branch circuit protection (BCP), motor control (contactor or other device), and an overload device.

Chapter 2.36, One-Port surge protection device (SPD), is a new description for a surge protection device that does not have a means of applying current to the load. Because it cannot apply current to the load, a one-port SPD does not need to have an SCCR rating. UL 508A, SB4.2.1 contains more information about these devices.

Chapter 2.44 contains the following definition for SCCR: “the fault current at a nominal voltage to which an apparatus or system is able to be connected without sustaining damage exceeding the defined acceptance criteria” (as defined in UL 508A, April 24, 2018).

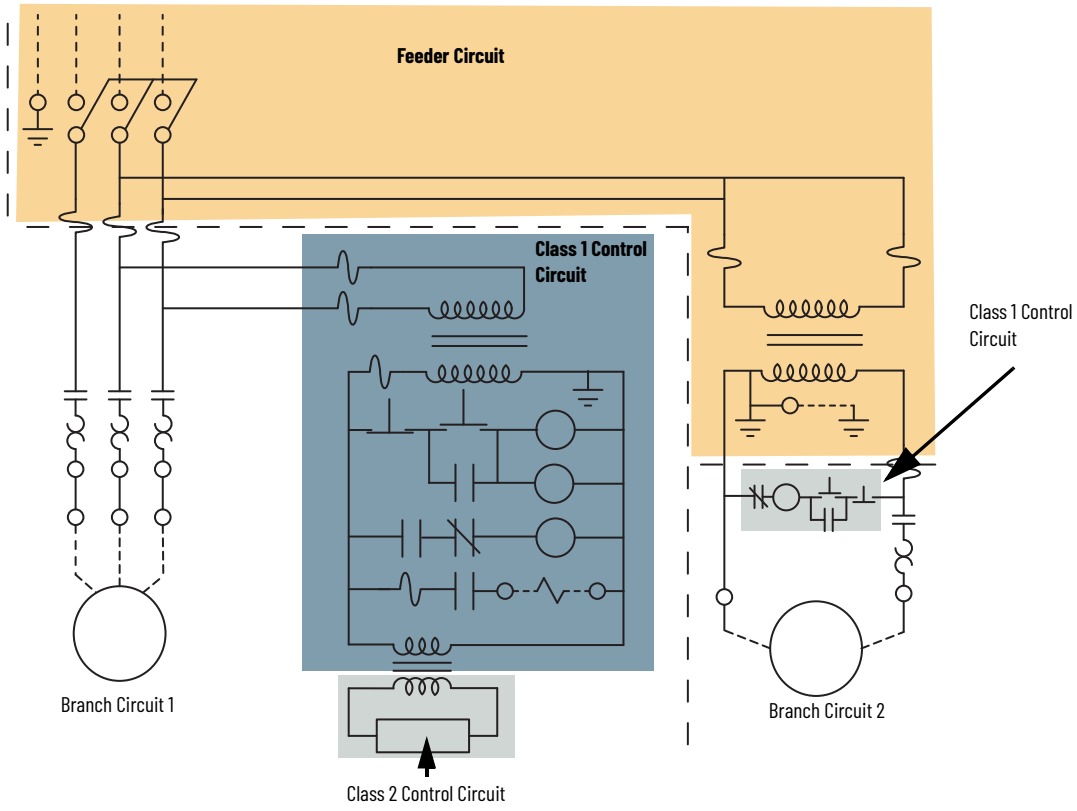
Table SB4.4, three-phase transformer secondary table, has been updated with lower values than previous versions of the code.

Types of Circuits

Figure 1 depicts the four different potential circuits that you may find in a panel. Understanding the different circuits is important for understanding the SCCR of the panel.

- Feeder Circuit—feeder circuits supply the power to the supply side of the branch circuit overcurrent device. Typically, this consists of incoming cables, a disconnect switch, power distribution block, and so on, all the way to the line side of the last branch circuit device.
- Branch Circuit—branch circuits run from the branch overcurrent protection device to the load. These also include control circuits.
- Control Circuit—control circuits perform the on/off and other control functions in a panel.
- Power Circuit—a power circuit is every circuit minus the control circuits.

Figure 1 - Sample Circuit Diagram



Determine the SCCR of a Panel

According to UL 508A, Supplement SB, there are four basic steps you need to follow to determine the SCCR rating of a panel and comply with the standard.

1. Look at the individual power circuit components in each branch circuit according to SB4.2.
2. Look for any possible current limiting components to possibly modify SCCR according to SB4.3.
3. Determine the overall SCCR of the panel according to the explanation in SB4.4.
4. Add the SCCR marking to panel according to SB5.1.

Step 1: Examine the Power Circuit Components

This step helps you to determine whether your power components meet the ratings requirements for your application.

Paragraph SB4.2.1

Power circuit components are generally required to have short-circuit ratings. Some components, such as voltmeters, EMI filters, and power resistors, are exempt from these requirements. Paragraph SB4.2.1 lists additional components that do not require SCCR.

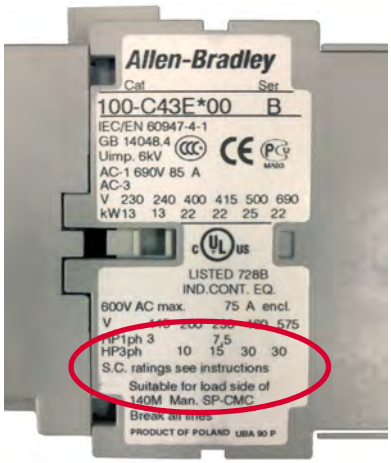
Table SB4.1 lists the default SCCR ratings for components that are not tested or marked.

Paragraph SB4.2.2

Paragraph SB4.2.2 requires that you use one of three values to determine the SCCR of the feeder or branch circuit component:

The first option is to use the manufacturer's tested rating, which you can find on the component label, packaging, or separate instruction sheet. See Figure 2.

Figure 2 - Manufacturer's Tested Rating Locations



Component label example

Size	Standard Fault Currents		High Available Fault Currents		
	Max. Fuse	Max. Circuit Breaker	Max. Class J Fuse	Max. Circuit Breaker	
	600 V max.		600 V max.	480 V max.	600 V max.
	XXX = 5'000 A		XXX = 100'000 A	XXX = 50'000 A	XXX = 30'000 A
43	150 A	125 A	70 A	50 A	50 A
55	200 A	150 A	-	-	-

Instruction sheet example

The second option is to use the values provided in Table SB4.1. Table SB4.1 provides the UL standard default short-circuit current ratings that you can use when your device is not marked or data is not provided by the manufacturer. This method is very conservative in nature.

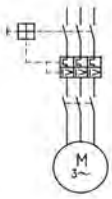
The final method of determining the SCCR of individual components is to use the product test data that is provided by the device manufacturer. Using this data ensures that any necessary testing has already been completed, typically with the appropriate branch circuit protection

Figure 3 shows an example of the data that Rockwell Automation provides via our Global SCCR Tool. Sometimes, the same product, depending on how it is used, will have different ratings. For this reason, we recommend that you verify ratings for every component or combination that you are using.

Figure 3 - Rockwell Automation SCCR Tool Sample Results

Short-circuit Coordination

Starter Type:	Direct-on-Line & Reversing - Trip Class 10 2C Starter: MPCB + Contactor
S.C. Protective Device:	140MG Motor Protection Circuit Breaker (MPCB) UL 489
Contactor:	100-C (100S-C)
Overload Relay:	---
Rated Operational Voltage:	460V 60Hz (480V Line)
Test Voltage:	483V 50Hz
Rated Conditional S.C. Current (Iq):	65kA (rms sym.)
Level of S.C. Coordination:	Type "2" per IEC 60947-4



Motor		Circuit Breaker			Contactor	IEC Coordination		
3 ph [HP]	1500 rpm [A] 1)	Catalog Number	Thermal Setting [A]	Magnetic Trip Current [A]	Catalog Number 2)	Coordination Type	Test Summary Letter	Remark
7 1/2	11	140MG-H8E-C25	10...25	150...325	100-C30...	Type 2	TS-1235-1A	---
10	14	140MG-H8E-C25	10...25	150...325	100-C30...			---
15	21	140MG-H8E-C25	10...25	150...325	100-C30...			---
20	27	140MG-H8E-C60	24...60	360...780	100-C30...			---
25	34	140MG-H8E-C60	24...60	360...780	100-C37...			---
30	40	140MG-H8E-C60	24...60	360...780	100-C43...			---
40	52	140MG-H8E-C60	24...60	360...780	100-C55...			---
50	65	140MG-H8E-D10	40...100	600...1300	100-C72...			---
60	77	140MG-H8E-D10	40...100	600...1300	100-C85...			---
75	96	140MG-H8E-D10	40...100	600...1300	100-C97...			---
100	124	140MG-J8E-D15	60...150	900...1950	100-E146...		---	---

Heavy Duty Starting and High Inrush Motors may require oversizing of circuit breaker and/or contactor

1) Typical motor current per NEC Article 430, Table 430-150
2) Incomplete catalog number, add coil code and auxiliary contacts

Paragraph SB4.2.3

Paragraph SB4.2.3 states that you can only use the specified breaker or fuse for high fault SCCR for a feeder or branch component as indicated in SB4.2.2 (a) or (c). There are four exceptions to this rule.

- A branch fuse of a different class can be substituted where the peak let-through current and I^2t of the new fuse is not greater than that of the specified fuse.
- If marked in accordance to SB5.1.2, a branch circuit protection can be provided in the field.
- A listed circuit breaker marked 'current limiting' can be replaced by another current-limiting circuit breaker if the I^2t and peak let-through are not greater than the specified breaker.
- A specified non-current limiting device can be replaced by a current limiting fuse that has an interrupting rating no less than the specified fuse and where the rated current is less than or equal to the rated current. You can use Table SB4.2 to obtain these values.

Step 2: Identify current-limiting components

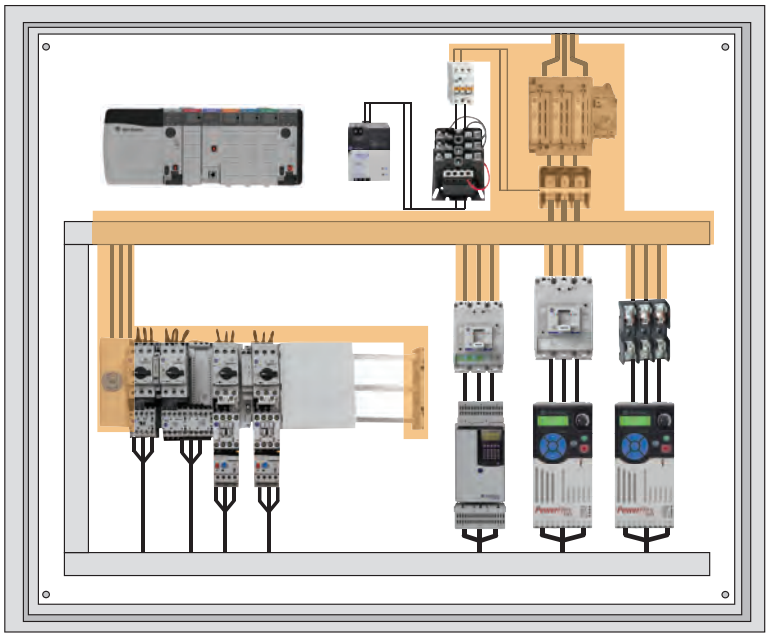
Paragraph SB4.3 guides you through determining SCCR for current-limiting devices. The sections of note are:

- SB4.3—Limiting short circuit current via feeder components
- SB4.3.1—Power transformer with an isolated secondary winding
- SB4.3.2—Circuit breaker is UL Listed as "Current Limiting"
- SB4.3.3—Fuses: Class CC, G, J, L, RK1, RK5, or T

Paragraph SB4.3

You need to identify which components of your installation are considered feeder components. Remember, feeder circuits supply the power to the supply side of the branch circuit overcurrent device. Figure 4 shows an example of a feeder circuit. In this case, the rotary disconnect switch, power distribution block, and the busbar mounting system are all part of the feeder circuit.

Figure 4 - Feeder Circuit



Paragraph SB4.3.1

Paragraph SB4.3.1 applies to a power transformer with an isolated secondary winding. There are two methods that you can use to determine the SCCR of the transformer. The transformer load-side components and protective devices need to be greater or equal to the calculated rating of the transformer in order to have the line-side interrupt rating of the primary overcurrent device be the SCCR.

For a power transformer with marked or known impedance, use the following formulas to calculate the secondary short-circuit current.

- Single-phase transformers: $I_{FL} = \frac{kVA * 1000}{V_{LL}}$ $I_{SC} = \frac{I_{FL}}{Z}$
- Three-phase transformers: $I_{FL} = \frac{kVA * 1000}{V_{LL} * \sqrt{3}}$ $I_{SC} = \frac{I_{FL}}{Z}$

I_{FL} = Full-load current
I_{SC} = Short-circuit current
Z = Impedance
V_{LL} = Line-to-line secondary voltage
kVA = Transformer kVA

The secondary voltage is expressed as line to line. If you do not know the impedance, you can use a default of Z = 2.1%.

For a power transformer with unmarked impedance or known impedance 2.1% or higher, you can use Tables SB4.3 or SB4.4 to obtain the secondary SCCR for the secondary short-circuit current power transformer with isolated secondary. If neither of the preceding methods is successful, then secondary-side SCCR is the lowest SCCR of the components or the lowest interrupting rating of the transformer load side (whichever is lowest).

Paragraph SB4.3.2

Paragraph SB4.3.2 applies to UL Listed circuit breakers that are marked, “current-limiting”. The two most important attributes to consider are:

- Peak let-through current
- Interrupt rating

Paragraph SB4.3.2 a) states that all of the downstream branches have to be rated above the peak let-through current of the feeder breaker and the rating of the branch protective device or combination controller must be equal to or greater than the available short-circuit current for the feeder circuit breaker.

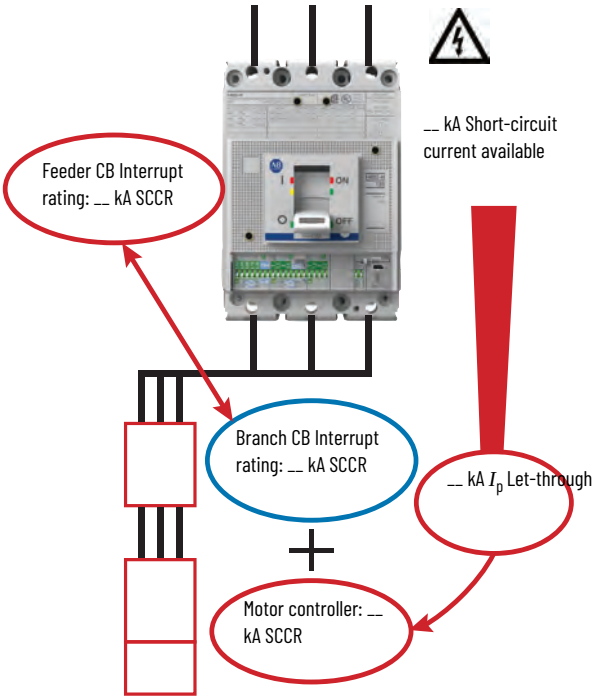
If SB4.3.2 a (peak let-through current requirement) is met, and one of the following are true, then you must use the smallest SCCR of the combination motor controller or interrupt rating of the branch device.

- the rating of the branch circuit device or combination controller is less than the interrupting rating of the feeder circuit breaker
- the rating of the branch circuit device or combination controller is less than available short circuit current for the feeder breaker

Essentially, what this means is if all the downstream branches have an SCCR greater than the peak let-through current, use the smallest of either the branch’s SCCR rating or the feeder’s interrupt rating.

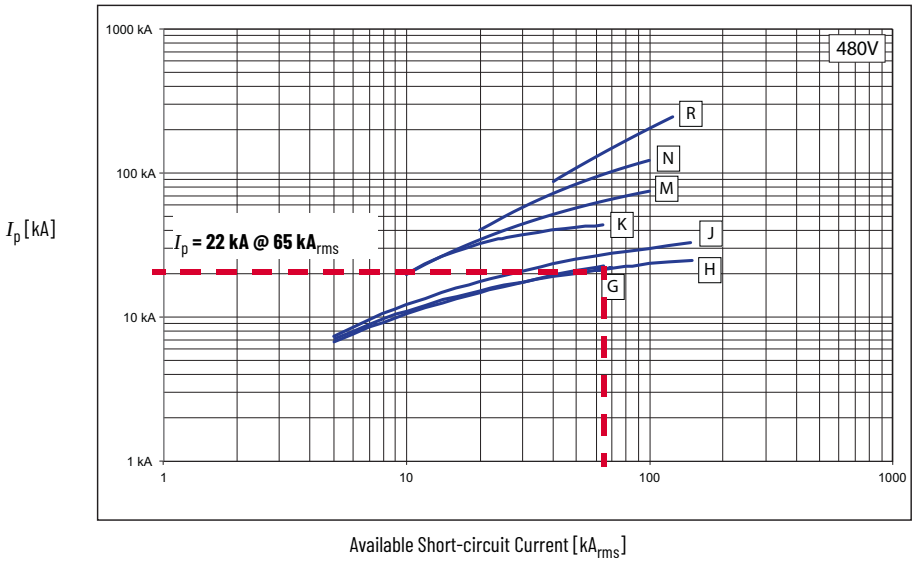
If neither of the above requirements nor the current-let-through requirement are met, then the SCCR is the smallest SCCR of any branch on the load side of the feeder. Figure 5 shows an example of the components on a branch circuit.

Figure 5 - Circuit Breaker Branch Circuit Diagram—Unrated



Because not all maximum let-through limits are the same for listed circuit breakers, you must check the manufacturer's let-through limits for the specific breaker that you are using. Figure 6 shows an example of a let-through current limit curve that is supplied by a manufacturer.

Figure 6 - Manufacturer's Let-through Current Limit Curve

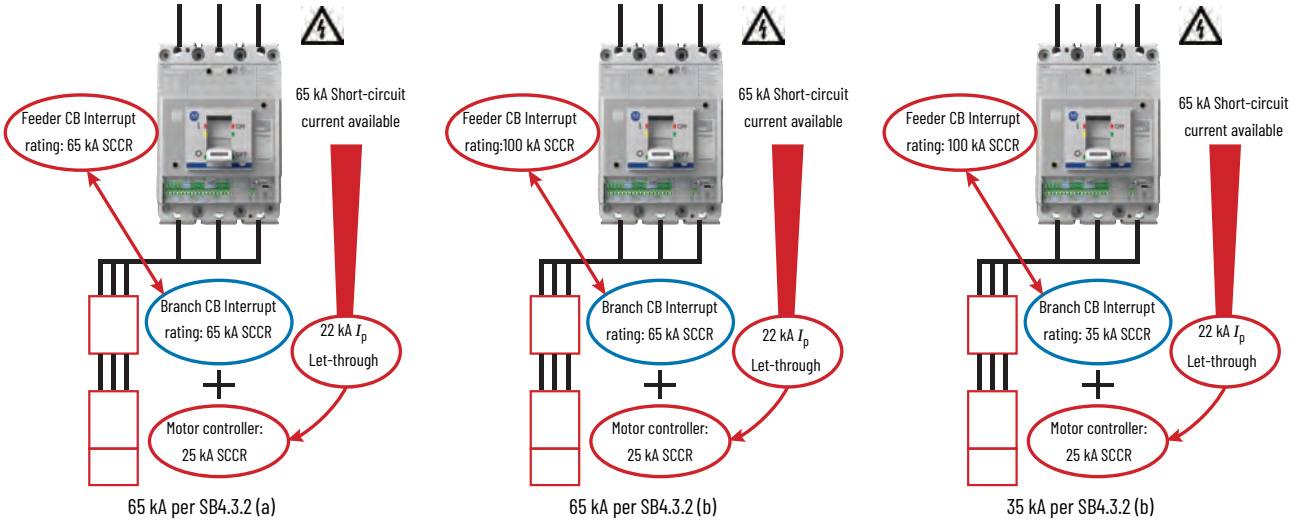


EXAMPLE: Determine Circuit Breaker Panel Ratings

Figure 7 shows three different scenarios for a panel branch circuit. We will use the curve in Figure 6 to determine the peak let-through current for the breaker. With 65 kA$_{rms}$ short-circuit current available, the peak let-through current is 22 kA.

Note the difference between the Feeder circuit breaker and the branch circuit breaker in these scenarios below. Even though the feeder circuit breaker on the second panel is 100 kA, the panel will only be 65 kA because of the rating of the branch circuit breaker.

Figure 7 - Circuit Breaker Panel Branch Circuit Diagrams



Paragraph SB4.3.3

Paragraph SB4.3.3 applies to branch circuits that are protected by Class CC, G, J, L, RK1, RK5 or T fuses in the feeder circuit. Like the requirements for circuit breakers, there are two important aspects to consider.

- Peak let-through current
- Interrupt rating

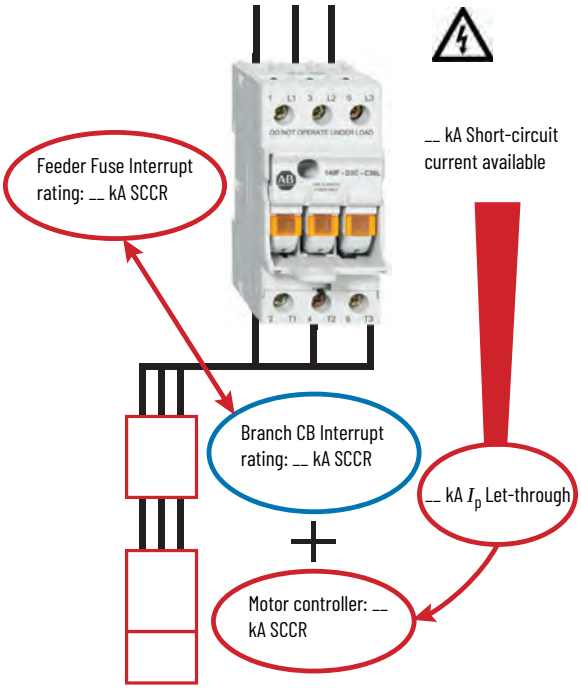
There are three subsections in Paragraph SB4.3.3:

a. The short-circuit current on the line side of the feeder fuse cannot exceed the SCCR of the branch interrupting rating or combination controller rating. Branch circuit devices need to have an SCCR greater than or equal to the peak let-through of the feeder fuse. Table SB4.2 determines peak let-through current based on fuse class and ampere rating.

b. If the branch circuit protective device interrupt rating or the SCCR of the combination controller in the branch is less than the feeder fuse, then the aforementioned branch protection or combo controller ratings are used.

c. If SB4.3.3 (a) and (b) are not met, the SCCR defaults to the smallest SCCR of any branch circuit on the load side of the feeder fuse.

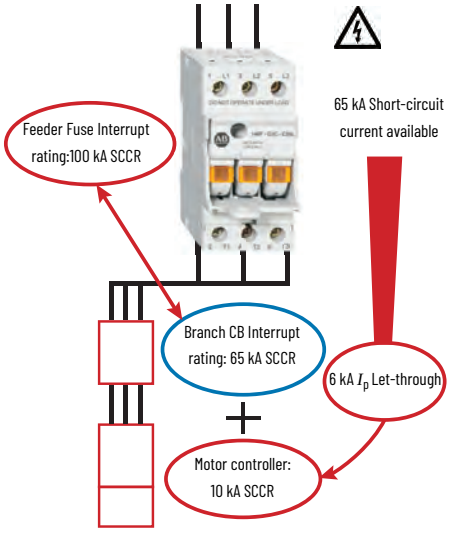
Figure 8 - Fused Branch Circuit Diagram—Unrated



EXAMPLE: Determine Fused Panel Ratings

We need to use values from Table SB4.2 to determine the peak let-through current for the fuse. With 65 kA_{rms} short-circuit current available, the peak let-through current is 6 kA. Using Figure 9 and following SB4.3.2 b), the SCCR for the feeder and the branch is 65kA.

Figure 9 - Fused Panel Branch Circuit Diagram



Step 3: Determine the Overall SCCR of the Panel

After we evaluate the power components (SB4.2), and any possible current-limiting capabilities (SB4.3), we can determine the overall SCCR of the industrial panel.

SB4.4.1 says to use the smallest SCCR of all load-side power circuit components of a branch circuit, the control circuit overcurrent protection from SB4.2, and compare that to the SCCR of the BCPD. The smaller of the two ratings is assigned to the line side of the BCPD.

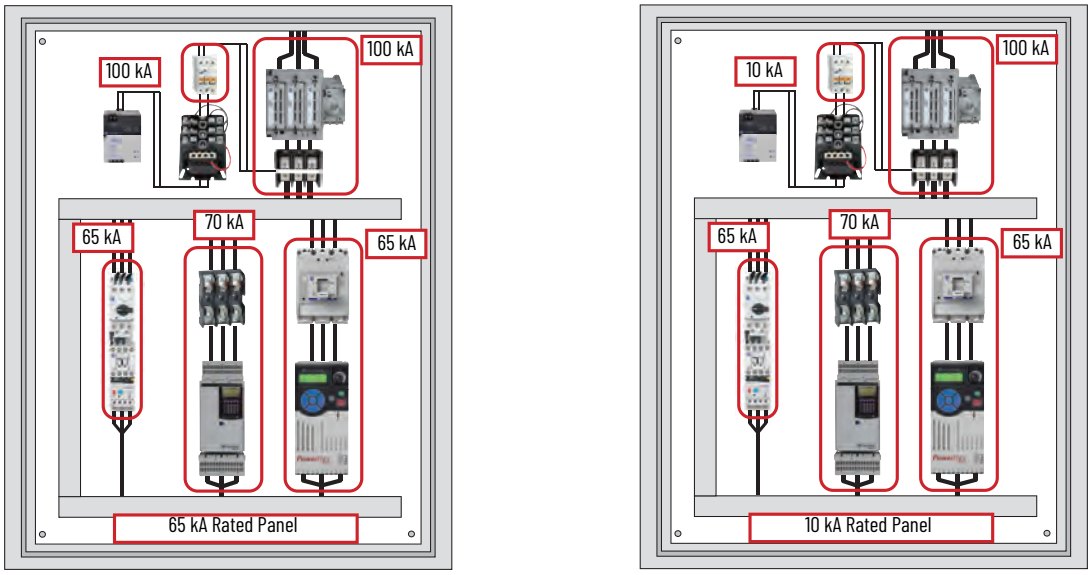
SB4.4.2 directs that the sources of the overall short circuit current rating shall be one of the following:

a. Single branch circuit without branch circuit protection—the lowest-rated component.
b. Single branch circuit with branch circuit protection—calculate per SB4.4.1.
c. Multiple branch circuits and feeder components within the panel—the lowest value of the following:

- The lowest short circuit current rating of any branch circuit in accordance with SB4.4.1 that has not been modified by SB4.3.1 – SB4.3.3
- The SCCR of any feeder component not covered by SB4.4.2(c)(3) and any control circuit overcurrent protection connected to the feeder as in SB3.2.1; or
- The modified short circuit current rating determined from SB4.3.1 – SB4.3.3 for each branch circuit that is supplied by the associated feeder component.

Figure 10 shows an example of two panel ratings that were calculated according to these guidelines.

Figure 10 - Panel Ratings per SB4.4



Step 4: Add the SCCR Marking to a Panel According to SB5.1

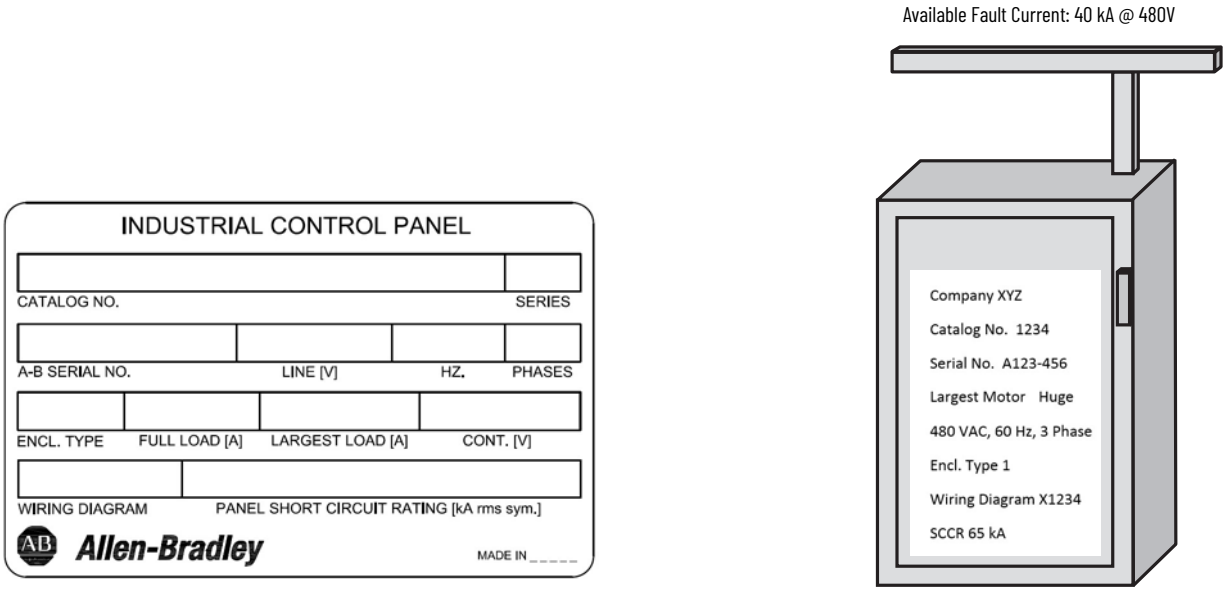
According to SB5.1, the nameplates of all industrial control panels must have the SCCR and the maximum voltage listed.

Paragraph SB5.1.2 determines the requirements for marking a panel that requires a field-installed BCPD. It simply says that the nameplates for all such panels must be marked with the size and type of BCPD that is required.

Paragraph SB5.1.3 says that, for any panel that is marked with a high-fault SCCR and is not provided with feeder circuit protection, the nameplate marking must include the type and size of any required field-installed feeder circuit protection device.

UL 508A 52.1, under “general markings”, states the requirements for panels. NEC 409.110 also details the marking requirements. Figure 11 shows an example of a panel label.

Figure 11 - Panel Label

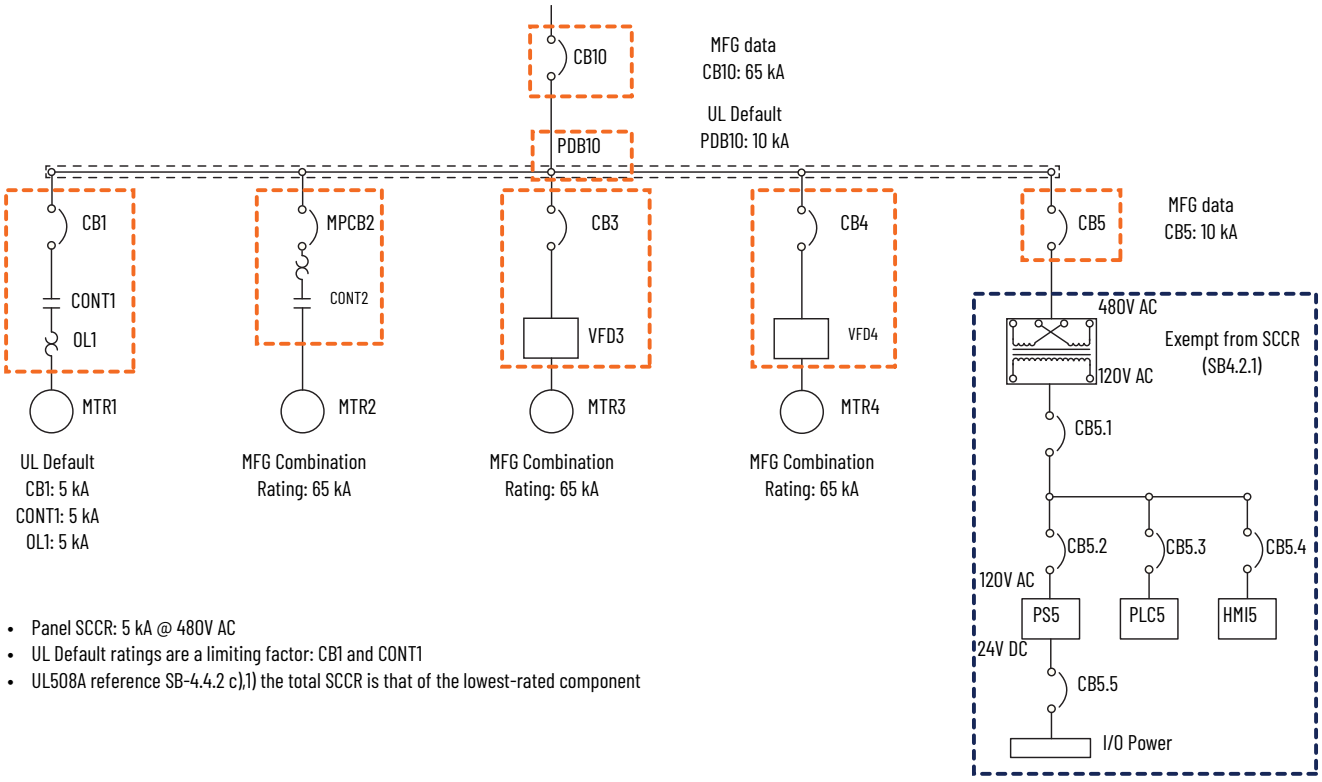


Example Circuit Diagrams

Mix of UL Default and Manufacturer Ratings

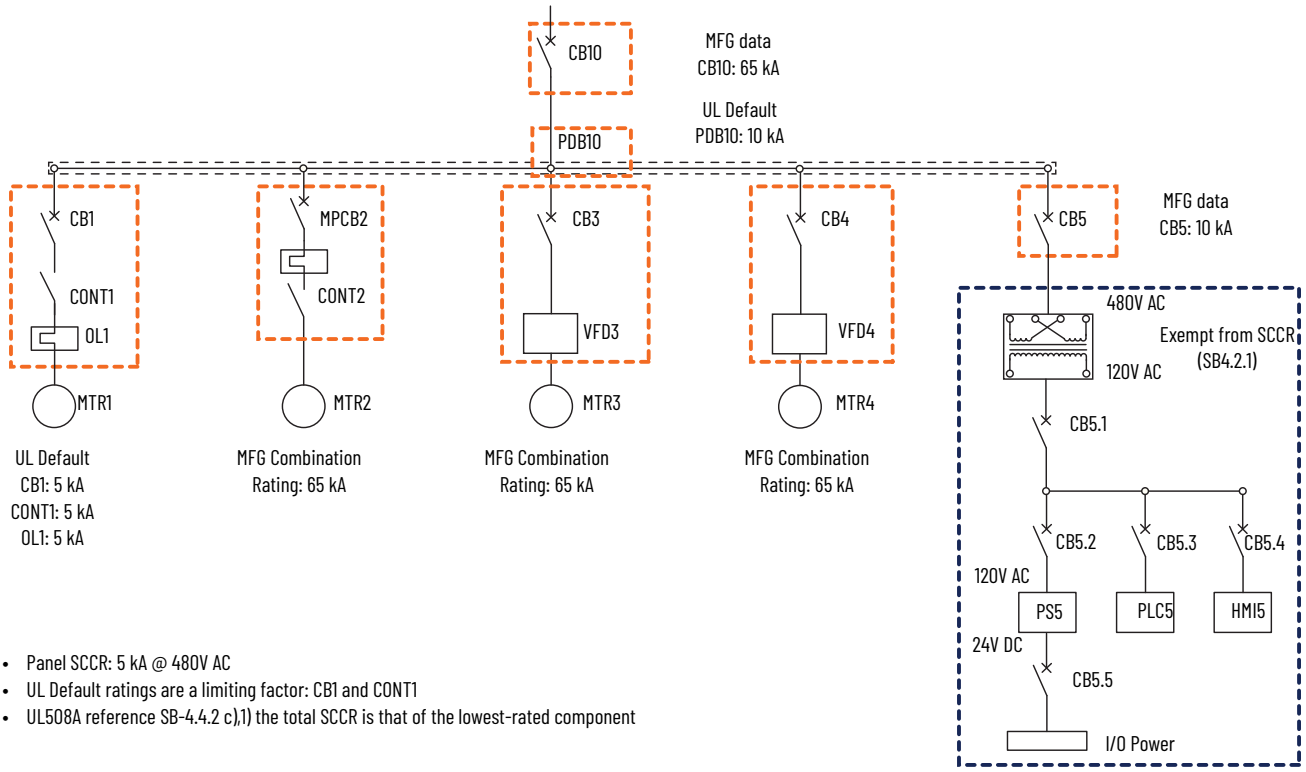
Figure 12 through Figure 19 show example wiring diagrams for various panel short-circuit ratings. All examples are shown with both IEC and NEMA nomenclature.

Figure 12 - 5 kA Panel Short-circuit Ratings—NEMA Nomenclature



- Panel SCCR: 5 kA @ 480V AC
- UL Default ratings are a limiting factor: CB1 and CONT1
- UL508A reference SB-4.4.2 c),1) the total SCCR is that of the lowest-rated component

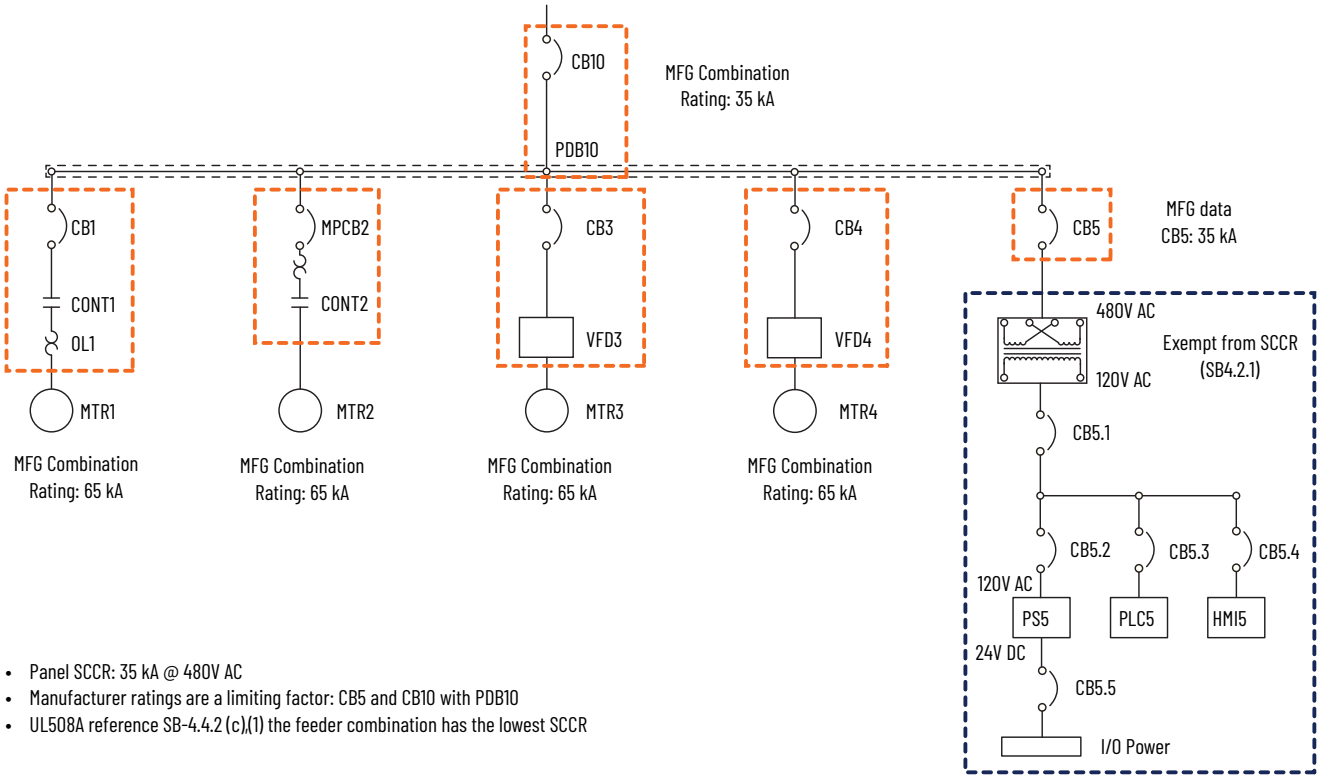
Figure 13 - 5 kA Panel Short-circuit Ratings—IEC Nomenclature



- Panel SCCR: 5 kA @ 480V AC
- UL Default ratings are a limiting factor: CB1 and CONT1
- UL508A reference SB-4.4.2 c),1) the total SCCR is that of the lowest-rated component

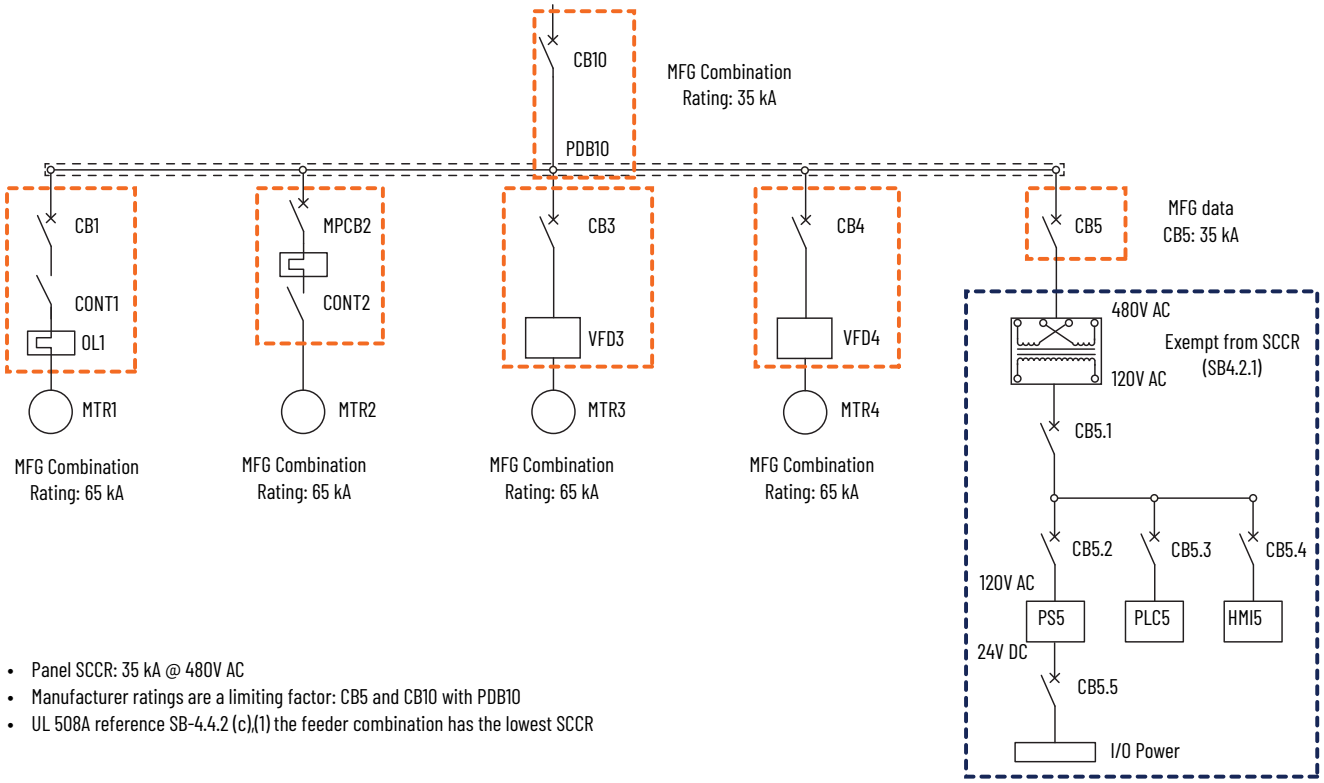
Manufacturer Ratings

Figure 14 - 35 kA Panel Short-circuit Ratings—NEMA Nomenclature



- Panel SCCR: 35 kA @ 480V AC
- Manufacturer ratings are a limiting factor: CB5 and CB10 with PDB10
- UL508A reference SB-4.4.2 (c),(1) the feeder combination has the lowest SCCR

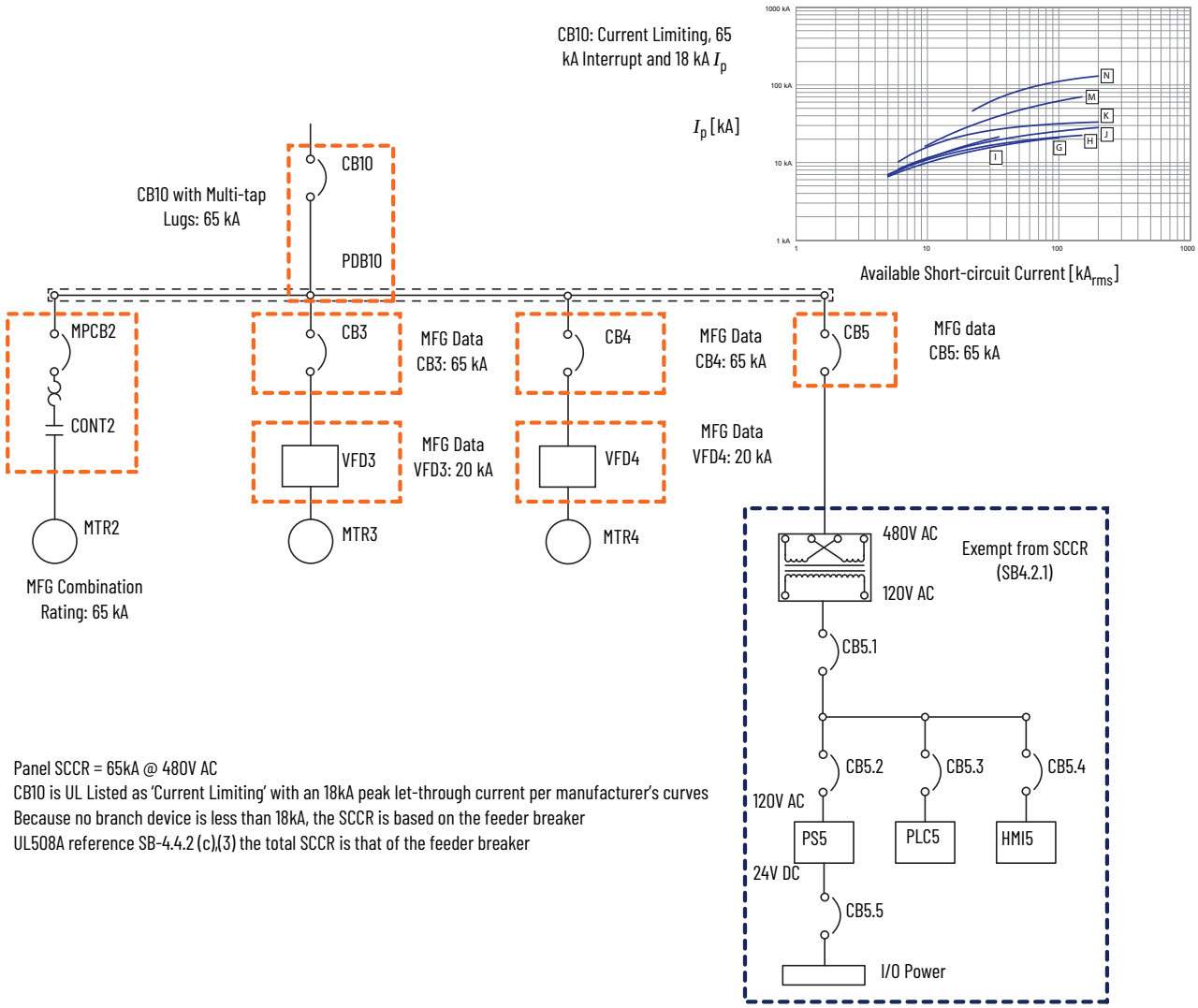
Figure 15 - 35 kA Panel Short-circuit Ratings—IEC Nomenclature



- Panel SCCR: 35 kA @ 480V AC
- Manufacturer ratings are a limiting factor: CB5 and CB10 with PDB10
- UL 508A reference SB-4.4.2 (c),(1) the feeder combination has the lowest SCCR

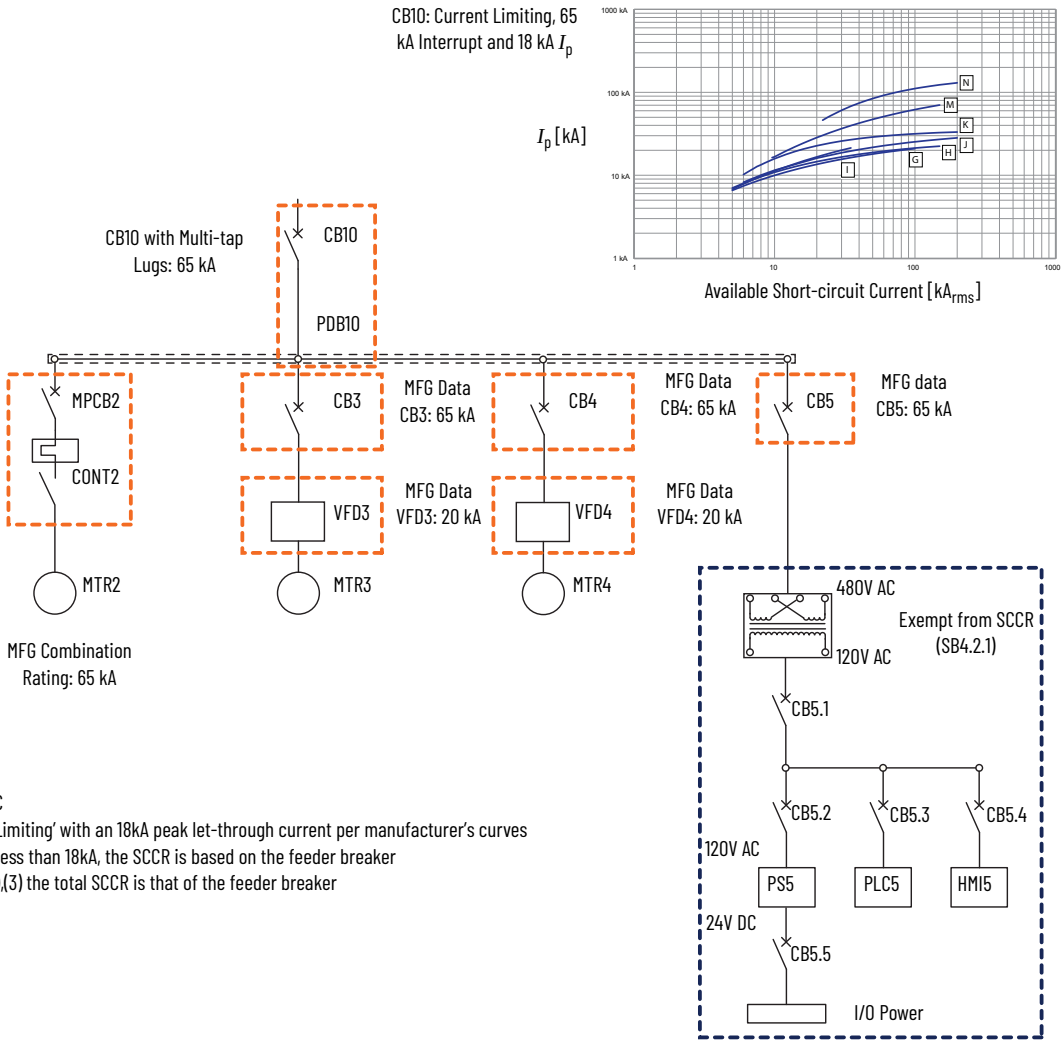
Current-limiting Circuit Breaker

Figure 16 - 65 kA Panel Short-circuit Ratings—NEMA Nomenclature



- Panel SCCR = 65kA @ 480V AC
- CB10 is UL Listed as 'Current Limiting' with an 18kA peak let-through current per manufacturer's curves
- Because no branch device is less than 18kA, the SCCR is based on the feeder breaker
- UL508A reference SB-4.4.2 (c),(3) the total SCCR is that of the feeder breaker

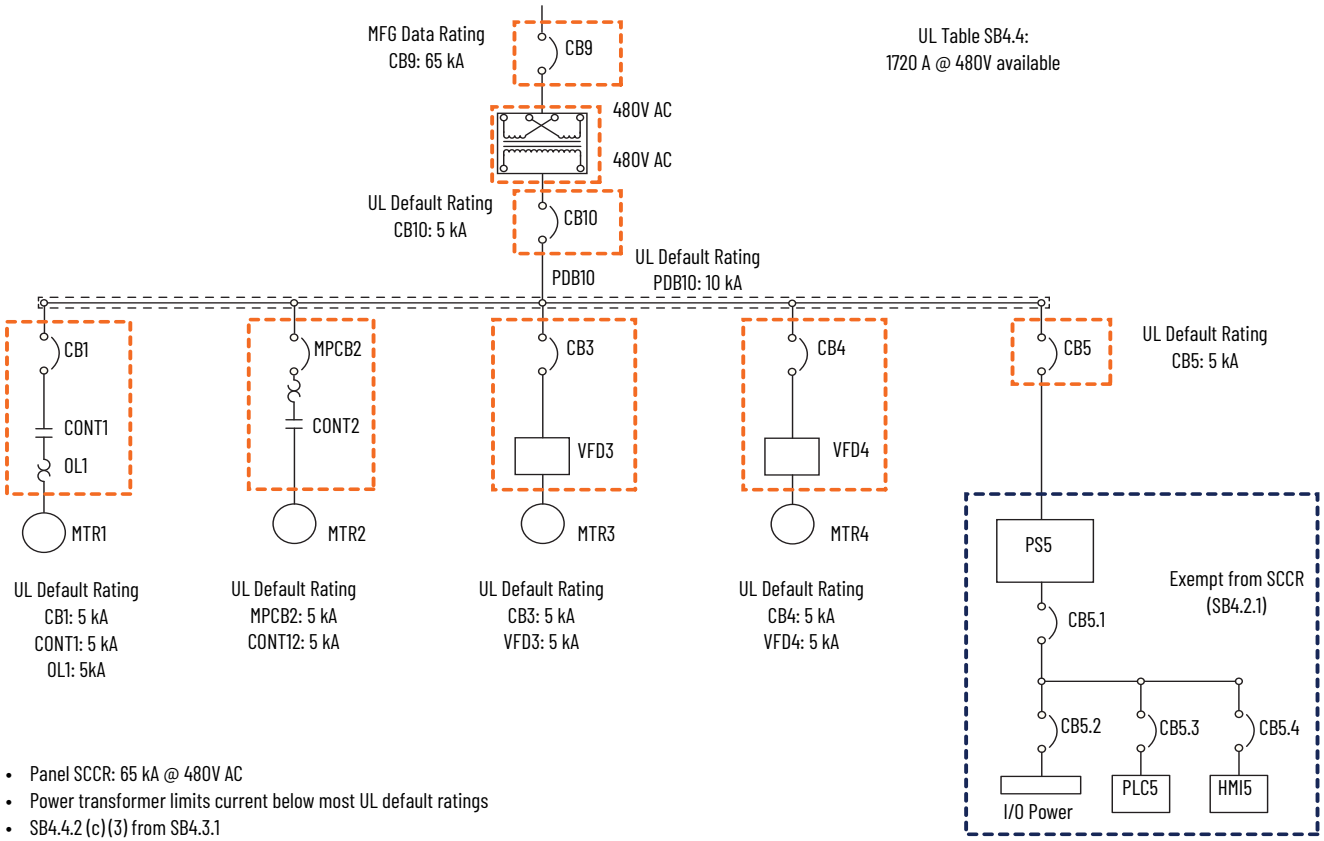
Figure 17 - 65 kA Panel Short-circuit Ratings—IEC Nomenclature



- Panel SCCR = 65kA @ 480V AC
- CB10 is UL Listed as 'Current Limiting' with an 18kA peak let-through current per manufacturer's curves
- Because no branch device is less than 18kA, the SCCR is based on the feeder breaker
- UL508A reference SB-4.4.2 (c),(3) the total SCCR is that of the feeder breaker

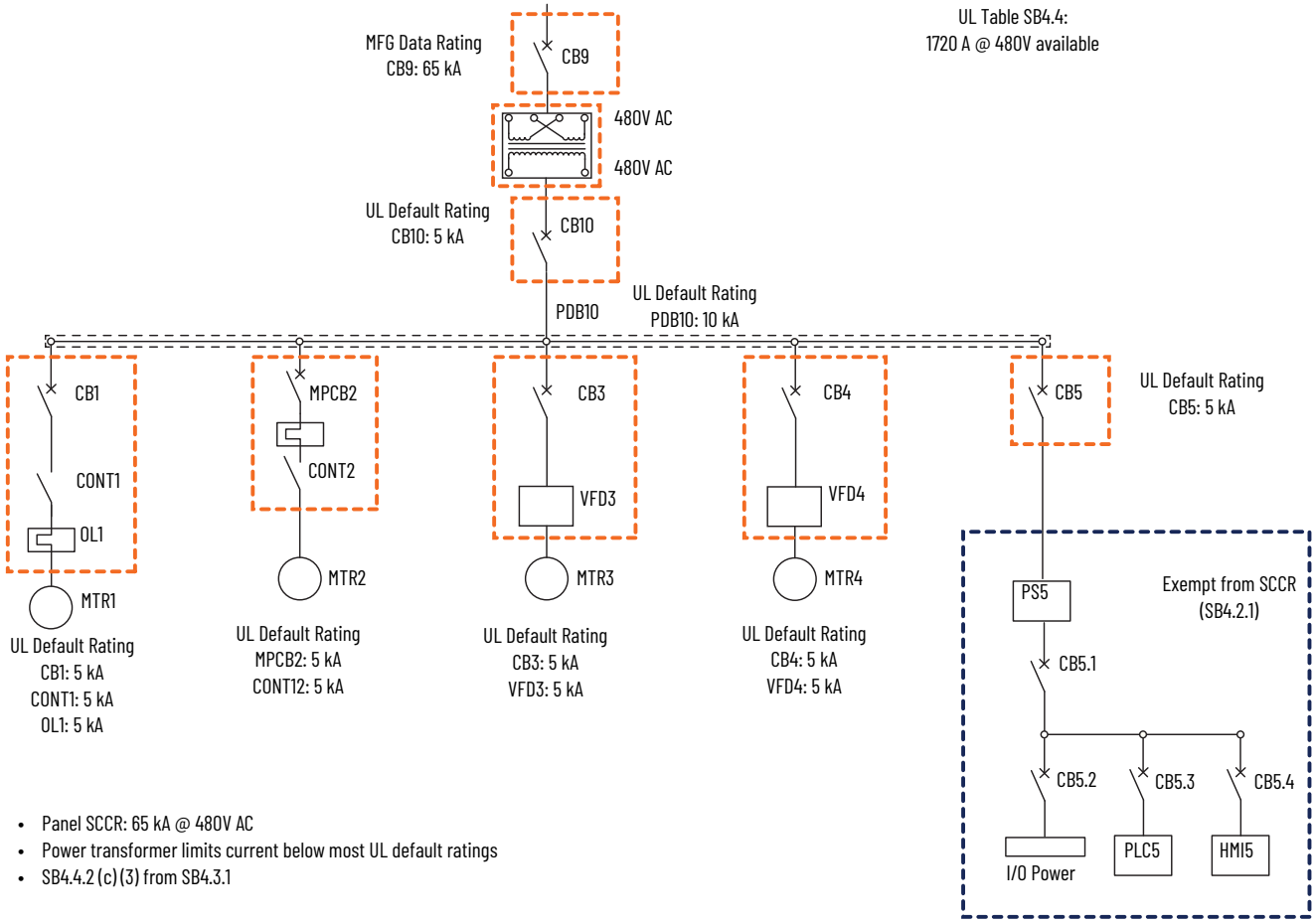
Current Limiting via Power Transformer

Figure 18 - 65 kA Transformer SCCR Ratings—NEMA Nomenclature



- Panel SCCR: 65 kA @ 480V AC
- Power transformer limits current below most UL default ratings
- SB4.4.2 (c) (3) from SB4.3.1

Figure 19 - 65 kA Transformer SCCR Ratings—IEC Nomenclature



Summary

Figure 20 through Figure 22 provide a flow chart summary of the SCCR process that is described in this document.

Figure 20 - Step 1: Evaluate Individual Power Circuit Components

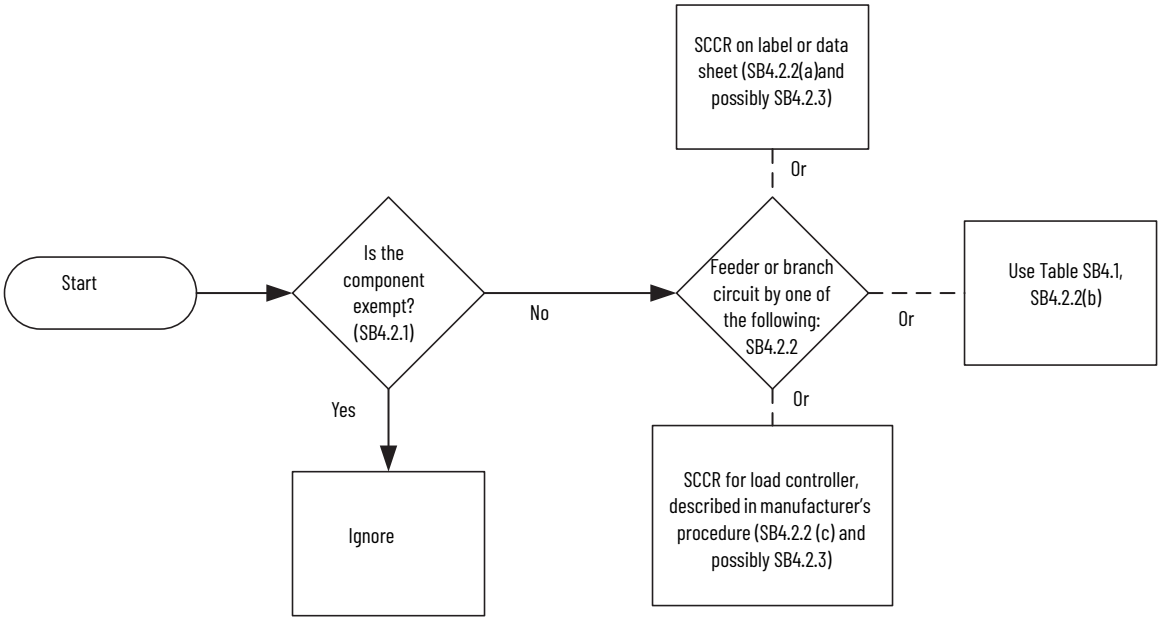


Figure 21 - Step 2: Look for Possible Current-limiting Options

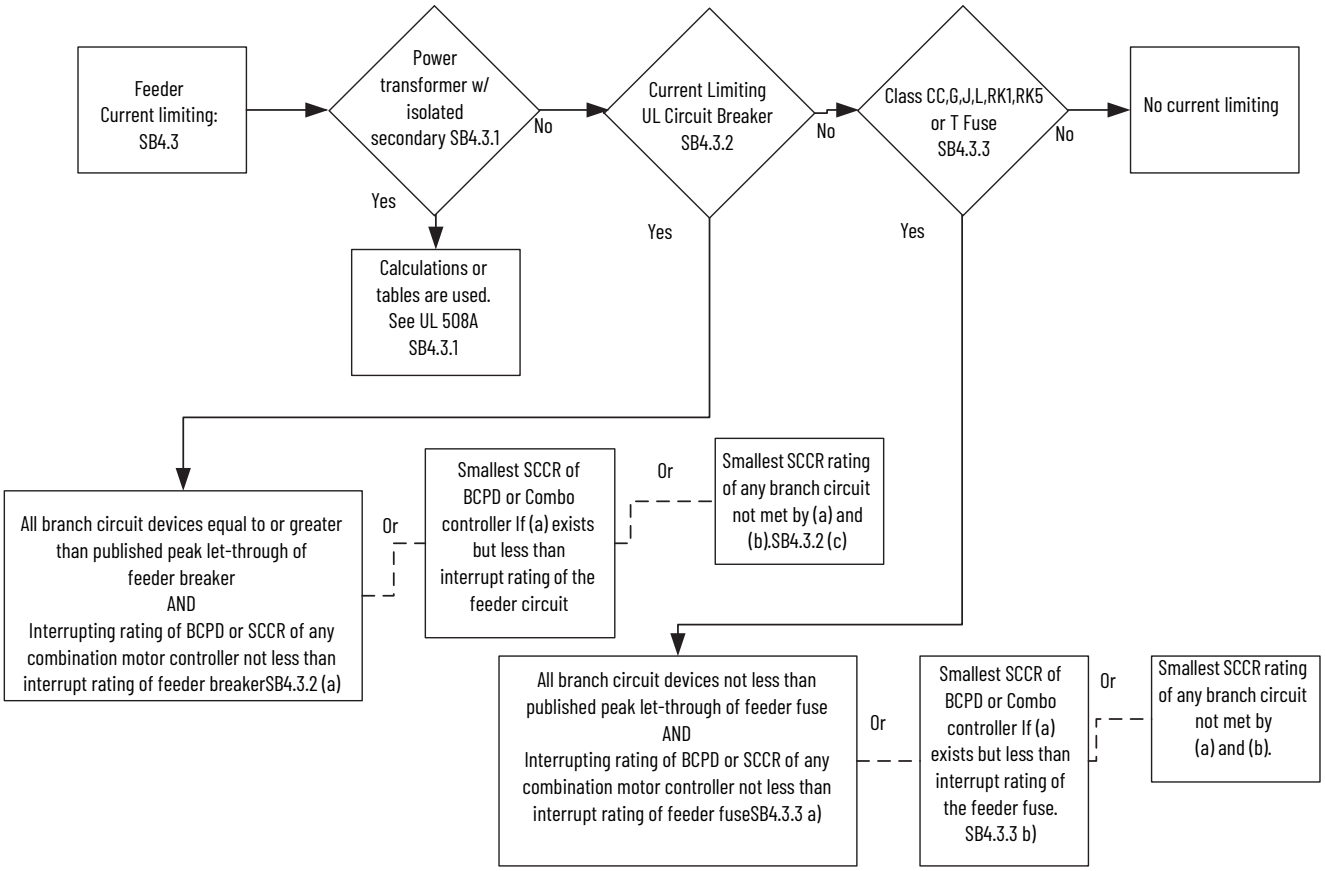
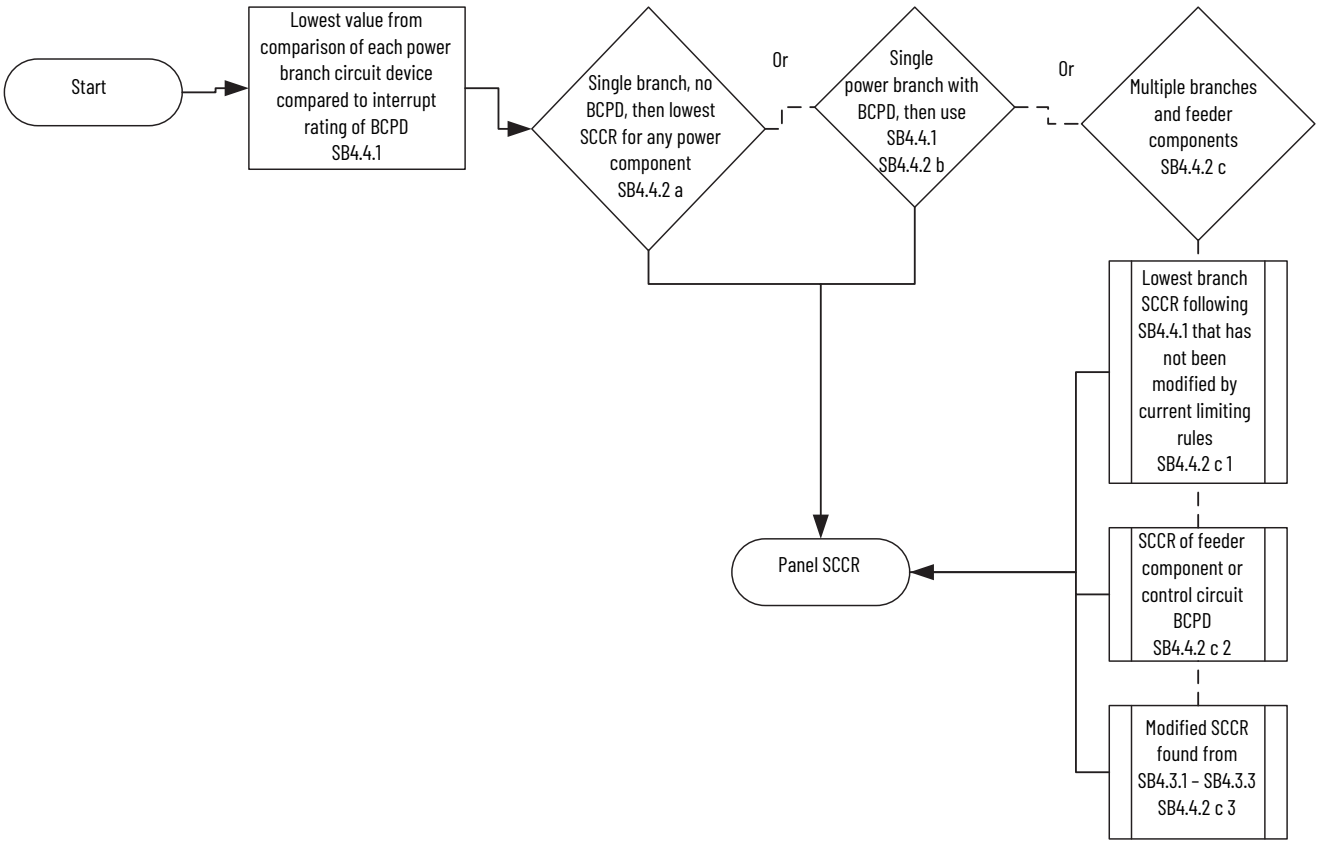


Figure 22 - Step 3: Overall Short-circuit Current Rating of the Panel



Additional Resources

These documents contain additional information concerning related products from Rockwell Automation.

Resource	Description
Molded Case Circuit Breaker Selectivity Guide, publication 1406-TD050	Provides assistance to choose a Molded Case Circuit Breaker (MCCB) or Miniature Circuit Breaker (MCB) for proper coordination in main (primary) and branch circuits.
North American Standards, Configurations, and Ratings: Introduction to Motor Circuit Design, publication IC-AT001	Provides an overview of North American motor circuit design, based on methods outlined in the NEC.
Circuit Protection Methods, publication 1492-WP001	Provides a guide to differentiating between various forms of circuit protection.
Protect and Disconnect: Complete Circuit and Load Protection Solutions, publication EC-BR005	Provides a guide to Rockwell Automation circuit protection devices.
Rockwell Automation Global SCCR Tool, rok.auto/sccr	Provides coordinated high-fault branch circuit solutions for motor starters, soft starters, and component drives.
Industrial Components Preventive Maintenance, Enclosures, and Contact Ratings Specifications, publication IC-TD002	Provides a quick reference tool for Allen-Bradley industrial automation controls and assemblies.
Safety Guidelines for the Application, Installation, and Maintenance of Solid-state Control, publication SGI-1.1	Designed to harmonize with NEMA Standards Publication No. ICS 1.1-1987 and provides general guidelines for the application, installation, and maintenance of solid-state control in the form of individual devices or packaged assemblies incorporating solid-state components.
Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1	Provides general guidelines for installing a Rockwell Automation industrial system.
Product Certifications website, rok.auto/certifications.	Provides declarations of conformity, certificates, and other certification details.

You can view or download publications at rok.auto/literature.

Rockwell Automation Support

Use these resources to access support information.

Technical Support Center	Find help with how-to videos, FAQs, chat, user forums, and product notification updates.	rok.auto/support
Knowledgebase	Access Knowledgebase articles.	rok.auto/knowledgebase
Local Technical Support Phone Numbers	Locate the telephone number for your country.	rok.auto/phonesupport
Literature Library	Find installation instructions, manuals, brochures, and technical data publications.	rok.auto/literature
Product Compatibility and Download Center (PCDC)	Download firmware, associated files (such as AOP, EDS, and DTM), and access product release notes.	rok.auto/pcdc

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Rockwell Automation maintains current product environmental compliance information on its website at rok.auto/pec.

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