Enhancing Short Circuit Selective Coordination with Low Voltage Circuit Breakers

Retain for future use.

INTRODUCTION

The purpose of this data bulletin is to present techniques for improving the short circuit selective coordination of low voltage circuit breakers used in electrical distribution systems.

It is a myth that only fuse based low voltage systems can be selectively coordinated. Modern molded case, insulated case and low voltage power circuit breakers provide the performance necessary to deliver higher levels of coordination than some have previously thought possible. This data bulletin demonstrates this fact.

The scope of this data bulletin encompasses only breaker to breaker short circuit selective coordination. Coordination with fuses and the protection of motors, transformers and other devices, as well as coordinated ground fault protection, is not discussed. See the **Reference** section, **on page 10**, for other data bulletins.

DEFINITIONS

See the **Glossary** in **Appendix—B, on page 21**, for a list of terms used in this data bulletin.

ASSUMPTIONS

A few assumptions have been made in the writing of this data bulletin:

Circuit Breaker Contact Position

It is assumed that all circuit breakers in the system, with the possible exception of the branch breaker nearest to the fault, are in the closed (ON) position when the fault occurs. Some circuit breakers, notably insulated case and low voltage power circuit breakers, may incorporate a making current release (MCR) trip function set slightly below the circuit breaker's close and latch rating. The MCR trip level may be below that of the adjustable instantaneous or instantaneous selective override trip functions.

Instantaneous Trip Setting

In order to maximize selective coordination, it is assumed that the instantaneous trip setting on all main and feeder breakers in the system, if adjustable, will be set to the highest position. It is also assumed that if the instantaneous trip function on electronic trip mains and feeders can be turned off it will be.

Turning off the instantaneous trip function does not mean that the circuit breaker loses its ability to protect against short circuits. Square D® electronic trip circuit breakers that have an OFF position on the instantaneous switch are also equipped with a short time pick-up and delay function, and may also be equipped with an instantaneous selective override function if necessary for the proper functioning of the circuit breaker.

CIRCUIT BREAKER BASICS

Before embarking on improving the design of a low voltage distribution system using circuit breakers so as to improve short circuit selective coordination, it would be helpful to know a few simple facts about circuit breakers that relate to selective coordination.

What a Circuit Breaker Must Protect

The primary function of a circuit breaker is to protect the downstream conductors connected to it. That is why virtually all circuit breakers are tested with a length of wire. However, the trip system inside the circuit breaker must also be able to protect the circuit breaker itself, as excessive current levels could damage the circuit breaker, rendering it unable to perform it's intended function. For this reason, circuit breakers with electronic trip systems may incorporate a making current release and/or an instantaneous selective override. When conducting a short circuit coordination study, the instantaneous selective override level needs to be considered.

This is not to say, of course, that circuit breakers are never applied in load protection applications as opposed to conductor protection applications. Certainly they are, but special protection studies must be conducted in such instances utilizing the circuit breaker trip curves and are not within the scope of this guide.

Continuous Current Rating Overlap

Circuit breaker manufacturers typically provide some overlap in the continuous current (handle) ratings of progressively larger frame size circuit breakers. For example, current ratings for 150, 250 and 400 A circuit breaker frames might be 15–150 A, 150–250 A, and 250–400 A respectively.

Electronic Trip Systems

The advantages of being able to adjust the trip curve of a circuit breaker equipped with an electronic trip system are obvious. But there are other advantages, such as being able to turn the instantaneous trip function off on some circuit breakers and models of trip units and the ability to select lower rated current sensors.

Adjustable Trip Settings

It should be noted that all adjustable trip settings on Square D® low voltage circuit breakers, with the exception of the ampere rating switch (also known as Ir or long time pick-up), are set to their lowest position in the factory prior to shipment. Thus, in order to realize the selective coordination planned, these settings may need to be adjusted in the field.

Series Ratings

The adjustment of trip settings does not affect any series rating that may be employed as UL® requires series ratings tests to be conducted with the instantaneous trip adjustment set to its highest position.

BASIC INFORMATION NEEDED

System One-line Diagram

A one-line diagram of the system to be studied is absolutely necessary in order to determine the level of system coordination.

System Voltage

While the system voltage, in and of itself, has no impact on selective coordination, it does impact circuit breaker selection, which in turn impacts coordination; thus the system voltage needs to be known.

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Circuit Ampacity

The instantaneous trip characteristics of a circuit breaker are more often a function of the frame or current sensor rating rather than the current rating of the circuit breaker. However, the current rating required to meet the ampacity of the circuit drives the circuit breaker selection, thus it needs to be known. (See NEC® Articles 210, 215, 220, 225 and 230.)

Available Short Circuit Current

The available short circuit current at each point in the system should be determined in order to select circuit breakers with the proper interrupting rating and in turn to determine the level of selective coordination.

DETERMINING THE SELECTIVE COORDINATION LEVEL

Based on the system one-line diagram, select the circuit breakers required throughout the system using catalog information or selection tools provided by the manufacturer. This will yield what will hence be referred to as the “standard” circuit breaker selection.

Determine Selective Coordination Levels

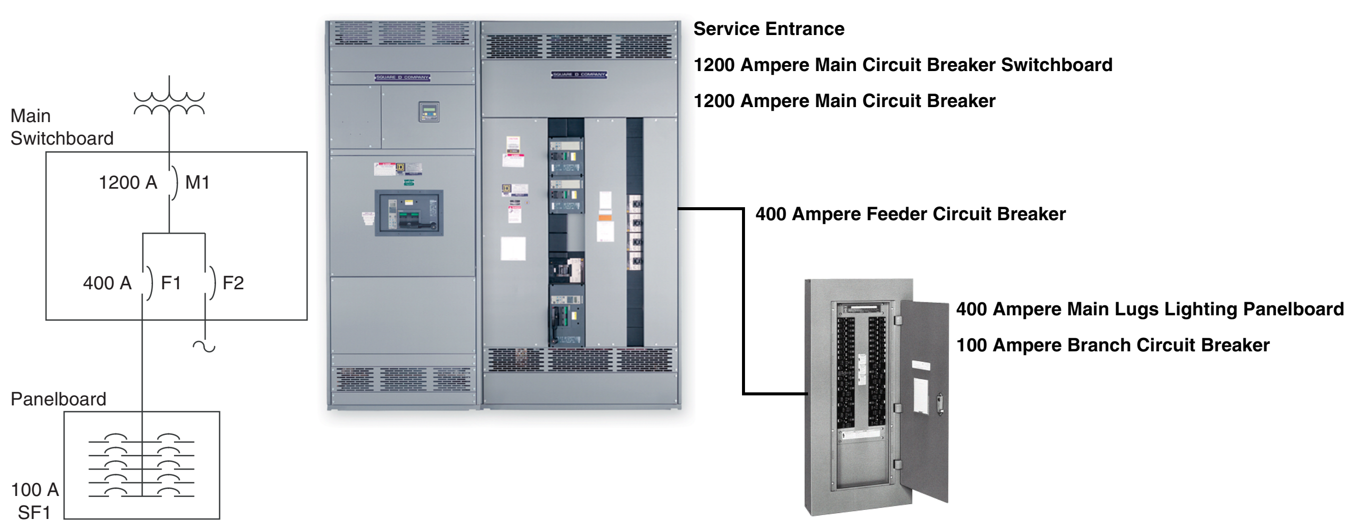
Determine the selective coordination of the standard circuit breaker selection by using trip curves, selective coordination software tools provided by the manufacturer or third parties, or the data presented in **Appendix—A, on page 11**.

Example

One manufacturer has published an example of a three tiered system consisting of a 1200 A molded case circuit breaker over a 400 A circuit breaker over a 100 A circuit breaker. The selective coordination analysis based on published trip curves showed the main breaker selectively coordinated up to 7,200 A. System voltage, available short circuit currents, and the type of equipment housing each circuit breaker, were not specified.

Figure 1, below, proposes what such an arrangement might look like in the real world, namely a 1200 A main breaker switchboard with a 400 A feeder breaker feeding a 400 A main lugs lighting panelboard with a 100 A branch breaker. Based on this configuration, a selective coordination study was conducted utilizing the method outlined above at 208 Y / 120 Vac and a 480 Y / 277 Vac with an assumed available short circuit current at the service entrance of 65 kA. Square D® circuit breakers and equipment were used in the analysis.

Figure 1: A Typical Three-tiered System



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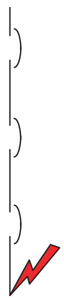
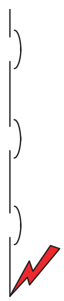
As can be seen in **Table 1** below, with no short circuit study and a standard circuit breaker selection, the system is selectively coordinated up to 21,600 A at the main and up to 3,000 A at the feeder on the 208 Y / 120 Vac system. On the 480 Y / 277 Vac system the circuit breakers are selectively coordinated up to 9,000 A at the main and up to 2,400 A at the feeder. These levels are "worst case," taking into account the tolerances of the instantaneous trip functions.

Table 1: Selective Coordination with a Standard Circuit Breaker Selection

One-line Diagram	Available Short Circuit Current (kA)	Circuit Breaker Ampacity (A)	Square D® Equipment	Square D® Circuit Breaker	Instantaneous Trip[1] (Amperes)	Instantaneous Selective Override Trip[2] (Amperes)	Maximum Selective Coordination Level[3] (Amperes)
208 Y / 120 Vac 65 kA Available Short Circuit Current							
	65	1200	I-Line® Switchboard	PGA36120U33A	OFF	21,600–26,400	21,600
	65	400	I-Line® Switchboard	LH36400	3,000–4,800	None	3,000
	65	100	NF Panelboard	EGB34100	1,725–2,760	None	—
	Fault						
480 Y / 277 Vac 65 kA Available Short Circuit Current							
	65	1200	I-Line® Switchboard	PJA36120U44A	OFF	9,000–11,000	9,000
	65	400	I-Line® Switchboard	LC36400	2,400–3,840	None	2,400
	65	100	NF Panelboard	EJB34100	1,725–2,760	None	—
	Fault						

1 Range shown is UL® 489 maximum allowable.
2 Range shown is from published literature.
3 Value shown takes into account the minimum tolerance of the upstream circuit breaker and the maximum tolerance of the downstream circuit breaker.

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One might argue that “in the real world” a 500 kVA transformer might feed a 1200 A 208 Y / 120 Vac system. Assuming a standard impedance of 5.0%, unlimited short circuit kVA available on the primary and 50% motor load, the secondary short circuit current would be only 30,600 A. Similarly, a 1000 kVA transformer might feed a 1200 A 480 Y / 277 Vac system. Assuming a standard impedance of 5.75%, unlimited short circuit kVA available on the primary and 100% motor load, the secondary short circuit current would be only 25,700 A. But for the purposes of illustrating how selective coordination can be improved to even higher levels than these, the assumed 65 kA available short circuit current level will continue to be used.

OPTIMIZING THE SELECTIVE COORDINATION LEVEL

Here are some suggestions on how to optimize selective coordination of a circuit breaker based low voltage system. **Appendix—A, on page 11**, lists the instantaneous trip levels of various Square D® low voltage circuit breakers and other pertinent information necessary to employ the suggestions listed below. The sample system illustrated in **Figure 1, on page 3**, is used to illustrate these techniques.

Conduct A Short Circuit Study

Conducting a short circuit study may reveal that lower interrupting rated circuit breakers can be selected at the feeder and branch levels, possibly resulting in higher withstand ratings.

Tables 2, 3 and 4 show standard rated branch breakers (10 kAIR for the 208 Y / 120 Vac system and 18 kAIR for the 480 Y / 277 Vac system). Is this assumption reasonable? Yes it is, as only 125 feet of #2 THHN in the 208 Vac system and 53 feet in the 480 Vac system would drop the available short circuit current at the branch to 10,000 A or 18,000 A respectively.

A Square D® PowerPact® PG circuit breaker has an instantaneous selective override set at 24,000 A nominal while the higher interrupting rated PJ circuit breaker has an instantaneous selective override set at 10,000 A nominal. Thus, had the lighting panel feeder breaker been located some distance from the service entrance, a lower interrupting rated PG circuit breaker might have been selected, increasing the maximum level of selective coordination.

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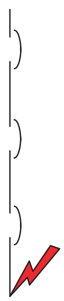
Increase Frame Size

As can be seen in **Table 2** below, by increasing the frame size of the main, the selective coordination at that level in the system can be increased from 21,600 A to 51,300 A and from 9,000 A to 43,200 A on the 208 Vac and 480 Vac systems respectively. This is possible because a 1200 A rating is available on the 2500 A PowerPact® R-frame unit mount circuit breaker. (Note that in a Square D® I-Line® switchboard, a 1200A PowerPact® R-frame I-Line® circuit breaker could also be selected as a back-fed main.)

By increasing the frame size of the feeder breaker, selective coordination at the feeder can be increased from 3,000 A to 21,600 A and from 2,400 to 9,000 A on the 208 Vac and 480 Vac systems respectively. This is possible because a 400 A rating is available on the 1200 A PowerPact® P-frame I-Line® circuit breaker.

Table 2: Improving Selective Coordination by Increasing the Frame Size of the Main and Feeder Circuit Breakers

One-line Diagram	Available Short Circuit Current (kA)	Circuit Breaker Ampacity (A)	Square D® Equipment	Square D® Circuit Breaker	Instantaneous Trip[1] (Amperes)	Instantaneous Selective Override Trip[2] (Amperes)	Maximum Selective Coordination Level[3] (Amperes)
208 Y / 120 Vac 65 kA Available Short Circuit Current at Service Entrance							
	65	1200	I-Line® Switchboard	RGF36120U33A	OFF	51,300–62,700	51,300
	65	400	I-Line® Switchboard	PGA36040U33A	OFF	21,600–26,400	21,600
	10	100	NQOD Panelboard	QOB3100	1,125–1,800	None	—
	Fault						
480 Y / 277 Vac 65 kA Available Short Circuit Current at Service Entrance							
	65	1200	I-Line® Switchboard	RJF36120U44A	OFF	43,200–52,800	43,200
	65	400	I-Line® Switchboard	PJA36040U33A	OFF	9,000–11,000	9,000
	18	100	NF Panelboard	EDB34100	1,725–2,760	None	—
	Fault						

1 Range shown is UL® 489 maximum allowable.
2 Range shown is from published literature.
3 Value shown takes into account the minimum tolerance of the upstream circuit breaker and the maximum tolerance of the downstream circuit breaker.

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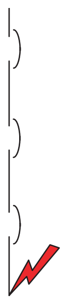
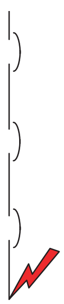
Table 3, below, illustrates what would result if the feeder breaker was a PowerPact® R-frame circuit breaker. In this case, the selective coordination level would be 51,300 A at 208 Vac and 43,200 A at 480 Vac. This is possible because PowerPact® R-frame I-Line® circuit breaker is available with a 600 A sensor and an adjustable rating plug that can be set to 0.75.

Table 3: Improving Selective Coordination by Increasing the Frame Size of the Feeder Circuit Breaker

One-line Diagram	Available Short Circuit Current (kA)	Circuit Breaker Ampacity (A)	Square D® Equipment	Square D® Circuit Breaker	Instantaneous Trip[1] (Amperes)	Instantaneous Selective Override Trip[2] (Amperes)	Maximum Selective Coordination Level[3] (Amperes)
208 Y / 120 Vac 65 kA Available Short Circuit Current at Service Entrance							
	65	1200	I-Line® Switchboard	RGF36120U33A	OFF	51,300–62,700	51,300
	65	400	I-Line® Switchboard	RGA36040CU33A	OFF	51,300–62,700	51,300
	10	100	NQOD Panelboard	QOB3100	1,125–1,800	None	—
	Fault						
480 Y / 277 Vac 65 kA Available Short Circuit Current at Service Entrance							
	65	1200	I-Line® Switchboard	RJF36120U44A	OFF	43,200–52,800	43,200
	65	400	I-Line® Switchboard	RJA36040CU33A	OFF	43,200–52,800	43,200
	18	100	NF Panelboard	EDB34100	1,725–2,760	None	—
	Fault						

1 Range shown is UL® 489 maximum allowable.
2 Range shown is from published literature.
3 Value shown takes into account the minimum tolerance of the upstream circuit breaker and the maximum tolerance of the downstream circuit breaker.

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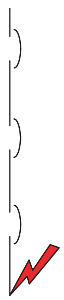
Change Circuit Breaker Type

As can be seen in **Table 4** below, by changing the main from a molded case to an insulated case circuit breaker, the selective coordination at that level in the system can be increased from 21,600 A to 58,500 A and from 9,000 A to 58,500 A on the 208 Vac and 480 Vac systems respectively. Once again, note that these levels are “worst case,” taking into account the tolerances of the instantaneous trip functions. But if the nominal instantaneous selective override trip level of 65,000 A was considered instead, the main breaker could be considered to be fully selective!

Table 4: Improving Selective Coordination by Changing the Main Circuit Breaker Type

One-line Diagram	Available Short Circuit Current (kA)	Circuit Breaker Ampacity (A)	Square D® Equipment	Square D® Circuit Breaker	Instantaneous Trip[1] (Amperes)	Instantaneous Selective Override Trip[2] (Amperes)	Maximum Selective Coordination Level[3] (Amperes)
208 Y / 120 Vac 65 kA Available Short Circuit Current							
	65	1200	I-Line® Switchboard	NW1200H	OFF	58,500–71,500	58,500
	65	400	I-Line® Switchboard	RGA36040CU33A	OFF	51,300–62,700	51,300
	10	100	NQOD Panelboard	QOB3100	1,125–1,800	None	—
	Fault						
480 Y / 277 Vac 65 kA Available Short Circuit Current							
	65	1200	I-Line® Switchboard	NW1200H	OFF	58,500–71,500	58,500
	65	400	I-Line® Switchboard	RJA36040CU33A	OFF	43,200–52,800	43,200
	18	100	NF Panelboard	EDB34100	1,725–2,760	None	—
	Fault						

1 Range shown is UL® 489 maximum allowable.
2 Range shown is from published literature.
3 Value shown takes into account the minimum tolerance of the upstream circuit breaker and the maximum tolerance of the downstream circuit breaker.

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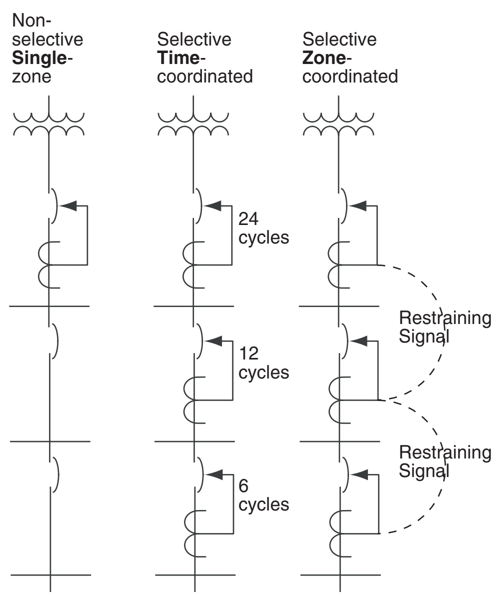
Although not illustrated, selective coordination on the 208 Vac system at the feeder can also be improved by changing from the standard Square D® LH circuit breaker to the LH-MC Mission Critical circuit breaker that has a higher withstand, and hence instantaneous trip level. Doing this would increase selective coordination at the feeder from 3,000 A to 5,400 A.

GROUND FAULT PROTECTION



Requirements and Use

Ground faults are one of the most common low voltage electrical system failures; thus ground fault protection is a good idea at any voltage. But on solidly grounded wye systems of more than 150 Vac to ground but not exceeding 600 Vac phase-to-phase, the National Electrical Code® (Article 230.95) requires the use of ground fault protection on service disconnects rated 1000 A or more. And, in health care facilities, the NEC® requires two levels of ground fault protection (Article 517.17), and requires them to be selectively coordinated.

Employing ground fault protection on feeder and branch circuits can not only minimize system damage but can interrupt the flow of fault current when it is still at a low level, thus preventing the possibility that upstream circuit breakers may trip. It is better to interrupt a fault current early when it is a low level ground fault rather than later when it has escalated into a high level phase-to-phase fault. Thus adding ground fault protection on feeder and branch breakers can improve selective coordination.

Zone Selective Interlocking

Selective ground fault protection coordination can be achieved by setting progressively higher pick-ups and time delays on upstream devices. But in order to minimize system damage should a ground fault occur somewhere in the “middle” of the system, such as in between the main and feeder, ZSI should be employed. Note that ZSI, in and of itself, does not provide selective coordination. Proper pick-up and time delay settings are required for coordination, with or without ZSI.

CONCLUSION

Consider the functions and characteristics of circuit breakers in order to enhance the design of selectively coordinated low voltage systems. As previously discussed, these include:

- **Instantaneous Trip Setting**—Some electronic trip units provide an OFF position on the instantaneous trip adjustment. This position can be used to enhance selective coordination without sacrificing the interrupting rating of the circuit breaker or any series ratings that may be available on the equipment in which the breaker is installed.
- **Continuous Current Rating Overlap**—The availability of lower continuous current ratings on higher amp frame circuit breakers can be used to enhance selective coordination as higher amp frame circuit breakers often have higher instantaneous trip levels.
- **Field Adjustment**—Do not neglect to properly adjust circuit breakers in the field as they are often shipped from the factory with all but the ampere-rating switch in the lowest position.

The methodology for evaluating the level of selective coordination between low voltage circuit breakers, is as follows:

- **Obtain a one-line diagram** of the system to be studied.
- **Determine the system** voltage and circuit ampacities.

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- **Make initial circuit breaker selections.**
- **Determine the selective coordination levels** between adjacent pairs of circuit breakers in the system.

Several optimizing techniques for enhancing the level of short circuit selective coordination in a low voltage circuit breaker system include:

- **Conduct a study** to determine the level of short circuit current available at various points in the system. This may allow the selection of circuit breakers with a lower interrupting rating and a higher instantaneous trip level.
- **Increase the frame size** of main or feeder breakers, thus increasing the instantaneous trip level of these breakers.
- **Change the type** of main or feeder breakers from molded case to insulated case or low voltage power, thus increasing the instantaneous trip level of these breakers.
- **Incorporate ground fault protection** into feeder and branch circuits so that low level ground faults will be cleared before they escalate into high level phase-to-phase faults.

Significant improvements in the selective coordination of low voltage circuit breaker based electrical distribution systems can be achieved by changing the circuit breaker selection. And as the examples have shown, very high levels of selectivity can be achieved.

REFERENCE

Overcurrent Protection
Document Number: 0600DB0301

Reducing Fault Stress with Zone-selective Interlocking
Document Number: 0600DB0001

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APPENDICES

APPENDIX—A

Instantaneous Trip Data for Square D® Low Voltage Circuit Breakers

Table 5: 240 Volt Circuit Breakers

Voltage Rating	Frame Size (Amperes)	Interrupting Rating (kA)	Circuit Breaker	Trip Unit Type	Continuous Current Range	Instantaneous Trip		Instantaneous Selective Override
		60 Hz			(Amperes)	Range (Amperes)[1]	Type	Trip Range (Amperes)[2]
Molded Case Circuit Breakers: UL® 489 Standard								
240	100	25	FA	T-M	15–30	275–600	Fixed	None
					35–50	400–850		
					60–80	800–1450		
					90–100	900–1700		
		65	FH		15–30	275–600		
					35–50	400–850		
					60–80	800–1450		
					90–100	900–1700		
		100	GJL		15–40	600–1200		
					50–100	800–1400		
		200	FI		20–30	275–600		
					35–50	400–850		
					60–80	800–1450		
					90–100	900–1700		
	125	25	ED		15–30	270–875		
					35–70	630–1800		
					80–125	1000–2300		
		65	EG		15–30	270–875		
					35–70	630–1800		
					80–125	1000–2300		
		100	EJ		15–30	270–875		
					35–70	630–1800		
					80–125	1000–2300		
	150	25	HD		15–30	350–750		
					35–50	400–850		
					60–90	800–1450		
					100–150	900–1700		
		65	HG		15–30	350–750		
					35–50	400–850		
					60–90	800–1450		
					100–150	900–1700		
		100	HJ		15–30	350–750		
					35–50	400–850		
					60–90	800–1450		
					100–150	900–1700		
		125	HL		15–30	350–750		
					35–50	400–850		
					60–90	800–1450		
					100–150	900–1700		

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Table 5: 240 Volt Circuit Breakers *(continued)*

Voltage Rating	Frame Size (Amperes)	Interrupting Rating (kA) 60 Hz	Circuit Breaker	Trip Unit Type	Continuous Current Range (Amperes)	Instantaneous Trip Range (Amperes)[1]	Instantaneous Trip Type	Instantaneous Selective Override Trip Range (Amperes)[2]
240	250	25	JD	T-M	150–250	5–10 x CCR	Adjustable	None
		65	JG					
		100	JJ					
		125	JL					
		200	KI		110–250			
		10	QB		70–90	1000–1800	Fixed	
					100–250	1200–2400		
		25	QD		70–90	1000–1800		
					100–250	1200–2400		
		65	QG		70–90	1000–1800		
					100–250	1200–2400		
		100	QJ[3]		70–90	1000–1800		
					100–250	1200–2400		
	400	25	Q4		250–400	5–10 x CCR	Adjustable	
		42	LA		125–400			
			LA-MC		200–250	17–20 x CCR	Fixed	
					400	15–18 x CCR		
		65	LH		250–400	5–10 x CCR	Adjustable	
			LH-MC		200–250	17–20 x CCR	Fixed	
					400	15–18 x CCR		
	600	65	DG	STR23SP	150–600	9 x In	Fixed	6,000
				STR53UP		1.5–7 x In	Adjustable	
		100	DJ	STR23SP		9 x In	Fixed	
				STR53UP		1.5–7 x In	Adjustable	
			LC	T-M	300–400	5 x CCR–3,200	Adjustable	None
					450–600	5 x CCR–4,200		
			LE	Micrologic®	100–600	OFF[4]		9 x P–11 x P
			LX			2.5–8 x P		
		125	DL	STR23SP	150–600	9 x In	Fixed	6,000
				STR53UP		1.5–7 x In	Adjustable	
		200	LI	T-M	300–400	5 x CCR–3,200	Adjustable	None
					450–600	5 x CCR–4,200		
			LXI	Micrologic®	100–600	2.5–8 x P		9 x P–11 x P
	800	65	MG	ET1.01	300–800	5–10 x CCR		None
		100	MJ					
	1200	65	PG, PK	ET1.01	600–1200	5–10 x CCR		21,600–26,400
				Micrologic®	100–1200	OFF[4]		
		100	PJ	ET1.01	600–1200	5–10 x CCR		9,000–11,000
				Micrologic®	100–1200	OFF[4]		
		125	PL	ET1.01	600–1200	5–10 x CCR		
				Micrologic®	100–1200	OFF[4]		

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Table 5: 240 Volt Circuit Breakers *(continued)*

Voltage Rating	Frame Size (Amperes)	Interrupting Rating (kA) 60 Hz	Circuit Breaker	Trip Unit Type	Continuous Current Range (Amperes)	Instantaneous Trip Range (Amperes)[1]	Instantaneous Trip Type	Instantaneous Selective Override Trip Range (Amperes)[2]
240	2500	65	RG, RK[5]	ET1.01	1200–2500	5–10 x CCR	Adjustable	51,300–62,700
				Micrologic®	240–2500	OFF[4]		
		100	RJ[5]	ET1.01	1200–2500	5–10 x CCR		43,200–52,800
				Micrologic®	240–2500	OFF[4]		
		125	RL[5]	ET1.01	1200–2500	5–10 x CCR		
				Micrologic®	240–2500	OFF[4]		
Insulated Case Circuit Breakers (Masterpact®): UL® 489 Standard								
240	800–1200	50	NT-N	Micrologic®	100–1200	OFF[4]	Adjustable	36,000–44,000
		65	NT-H					
		100	NT-L1					9,000–11,000
		200	NT-L					
			NT-LF					
	800–2000	65	NW-N		100–2000			36,000–44,000
		100	NW-H					
		200	NW-L		100–250			21,600–26,400
					400–1600			31,500–38,500
					2000			58,500–71,500
			NW-LF		100–2000			19,800–24,200
	2500–3000	100	NW-H		1200–3000			58,500–71,500
		200	NW-L					
	4000–6000	100	NW-H		2000–6000			67,500–82,500
		200	NW-L					
Low Voltage Power Circuit Breakers (Masterpact®): UL® 1066 / ANSI C37 Standards								
254	800	42	NT-N1	Micrologic®	100–800	OFF[4]	Adjustable	None[6]
			NT-L1F					9,000–11,000
			NW-N1		100–250			21,600–26,400
					400–800			None[6]
		65	NW-H1		100–250			21,600–26,400
					400–800			None[6]
		85	NW-H2		100–250			21,600–26,400
					400–800			None[6]
		100	NW-H3		100–800			76,500–93,500
		200	NW-L1		100–250			21,600–26,400
					400–800			31,500–38,500
			NW-L1F		100–800			21,600–26,400
	1600	42	NW-N1		800–1600			None[6]
		65	NW-H1					
		85	NW-H2					
		100	NW-H3					76,500–93,500
		200	NW-L1					31,500–38,500
			NW-L1F					21,600–26,400
	2000	65	NW-H1		1000–2000			None[6]
		85	NW-H2					
		100	NW-H3					76,500–93,500
		200	NW-L1					31,500–38,500
			NW-L1F					21,600–26,400
	3200	65	NW-H1		1600–3200			None[6]
		85	NW-H2					
		100	NW-H3					76,500–93,500
		200	NW-L1					105,300–128,700

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Table 5: 240 Volt Circuit Breakers *(continued)*

Voltage Rating	Frame Size (Amperes)	Interrupting Rating (kA) 60 Hz	Circuit Breaker	Trip Unit Type	Continuous Current Range (Amperes)	Instantaneous Trip Range (Amperes)[1]	Instantaneous Trip Type	Instantaneous Selective Override Trip Range (Amperes)[2]
254	4000	85	NW-H2	Micrologic®	2500–4000	OFF[4]	Adjustable	None[6]
		100	NW-H3					76,500–93,500
		200	NW-L1					105,300–128,700
	5000	85	NW-H2		2500–5000			None[6]
		100	NW-H3					76,500–93,500
		200	NW-L1					105,300–128,700

1 For thermal-magnetic circuit breakers with fixed instantaneous trip, the lower number is the “must hold” and the higher number the “must trip” value. For thermal-magnetic circuit breakers with adjustable instantaneous trip, the adjustment range shown is a function of the continuous current rating (CCR, aka ampere or handle rating) of the circuit breaker. The allowable UL tolerances are -20% (low) and +30% (high) from the nominal values shown. For electronic trip circuit breakers, the adjustment range shown is a function of the rating plug (P) or the sensor (In). Tolerances are +/-10% on both the low and high end of the range.

2 The range shown reflects manufacturing tolerances.

3 Rated 208 Y / 120 Vac.

4 Turning the instantaneous setting to OFF on Micrologic® electronic trip units will maximize short circuit selective coordination. An OFF setting is available on Micrologic® trip units with LSI or LSIG protection.

5 1200 amperes maximum in I-Line®.

6 This circuit breaker, with the instantaneous set to OFF, is fully selective up to the interrupting rating of the circuit breaker.

Table 6: 480 Volt Circuit Breakers

Voltage Rating	Frame Size (Amperes)	Interrupting Rating (kA) 60 Hz	Circuit Breaker	Trip Unit Type	Continuous Current Range (Amperes)	Instantaneous Trip Range (Amperes)[1]	Instantaneous Trip Type	Instantaneous Selective Override Trip Range (Amperes)[2]
Molded Case Circuit Breakers: UL® 489 Standard								
480 Y / 277 Vac	125	18	ED	T-M	15–30	270–875	Fixed	None
					35–70	630–1800		
					80–125	1000–2300		
		35	EG		15–30	270–875		
					35–70	630–1800		
					80–125	1000–2300		
		65	EJ		15–30	270–875		
					35–70	630–1800		
					80–125	1000–2300		
480	100	18	FA		15–30	275–600		
					35–50	400–850		
					60–80	800–1450		
					90–100	900–1700		
		25	FH		15–30	275–600		
					35–50	400–850		
					60–80	800–1450		
					90–100	900–1700		
		65	GJL		15–40	600–1200		
					50–100	800–1400		
		200	FI		20–30	275–600		
					35–50	400–850		
					60–80	800–1450		
					90–100	900–1700		

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Table 6: 480 Volt Circuit Breakers *(continued)*

Voltage Rating	Frame Size (Amperes)	Interrupting Rating (kA)	Circuit Breaker	Trip Unit Type	Continuous Current Range	Instantaneous Trip		Instantaneous Selective Override
		60 Hz			(Amperes)	Range (Amperes)[1]	Type	Trip Range (Amperes)[2]
480	150	18	HD	T-M	15–30	350–750	Fixed	None
					35–50	400–850		
					60–90	800–1450		
					100–150	900–1700		
		35	HG		15–30	350–750		
					35–50	400–850		
					60–90	800–1450		
					100–150	900–1700		
		65	HJ		15–30	350–750		
					35–50	400–850		
					60–90	800–1450		
					100–150	900–1700		
		100	HL		15–30	350–750		
					35–50	400–850		
					60–90	800–1450		
					100–150	900–1700		
	250	18	JD		150–250	5–10 x CCR	Adjustable	
		35	JG					
		65	JJ					
		100	JL					
		200	KI		110–250			
	400	30	LA		125–400	5–10 x CCR	Adjustable	
			LA-MC		200–250	17–20 x CCR	Fixed	
					400	15–18 x CCR		
		35	LH		250–400	5–10 x CCR	Adjustable	
			LH-MC		200–250	17–20 x CCR	Fixed	
					400	15–18 x CCR		
	600	35	DG	STR23SP	150–600	9 x In	Fixed	6,000
				STR53SP		1.5–7 x In	Adjustable	
		65	DJ	STR23SP		9 x In	Fixed	
				STR53SP		1.5–7 x In	Adjustable	
			LC	T-M	300–400	5 x CCR–3,200	Adjustable	None
					450–600	5 x CCR–4,200		
			LE	Micrologic®	100–600	OFF[3]		9 x P–11 x P
			LX			2.5–8 x P		
		100	DL	STR23SP	150–600	9 x In	Fixed	6,000
				STR53SP		1.5–7 x In	Adjustable	
		200	LI	T-M	300–400	5 x CCR–3,200	Adjustable	None
					450–600	5 x CCR–4,200		
			LXI	Micrologic®	100–600	2.5–8 x P		9 x P–11 x P
	800	35	MG	ET1.01	300–800	5–10 x CCR	Adjustable	None
		65	MJ					

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Table 6: 480 Volt Circuit Breakers *(continued)*

Voltage Rating	Frame Size (Amperes)	Interrupting Rating (kA) 60 Hz	Circuit Breaker	Trip Unit Type	Continuous Current Range (Amperes)	Instantaneous Trip Range (Amperes)[1]	Instantaneous Trip Type	Instantaneous Selective Override Trip Range (Amperes)[2]
480	1200	35	PG	ET1.01	600–1200	5–10 x CCR	Adjustable	21,600–26,400
				Micrologic®	100–1200	OFF[3]		
		50	PK	ET1.01	600–1200	5–10 x CCR		
				Micrologic®	100–1200	OFF[3]		
		65	PJ	ET1.01	600–1200	5–10 x CCR		9,000–11,000
				Micrologic®	100–1200	OFF[3]		
		100	PL	ET1.01	600–1200	5–10 x CCR		
				Micrologic®	100–1200	OFF[3]		
	2500	35	RG[4]	ET1.01	1200–2500	5–10 x CCR		51,300–62,700
				Micrologic®	240–2500	OFF[3]		
		50	RK[4]	ET1.01	1200–2500	5-10 x CCR		
				Micrologic®	240–2500	OFF[3]		
		65	RJ[4]	ET1.01	1200–500	5–10 x CCR		43,200–52,800
				Micrologic®	240–2500	OFF[3]		
		100	RL[4]	ET1.01	1200–2500	5–10 x CCR		
				Micrologic®	240–2500	OFF[3]		
Insulated Case Circuit Breakers (Masterpact®): UL® 489 Standard								
480	800–1200	50	NT-N	Micrologic®	100–1200	OFF[3]	Adjustable	36,000–44,000
		50	NT-H					
		65	NT-L1					9,000–11,000
		100	NT-L					
			NT-LF					
	800–2000	65	NW-N		100–2000			36,000–44,000
		100	NW-H					
		150	NW-L		100–250			21,600–26,400
					400–1600			31,500–38,500
					2000			58,500–71,500
			NW-LF		100–2000			19,800–24,200
	2500–3000	100	NW-H		1200–3000			58,500–71,500
		150	NW-L					
	4000–6000	100	NW-H		2000–6000			67,500–82,500
		150	NW-L					
Low Voltage Power Circuit Breakers (Masterpact®): UL® 1066 / ANSI C37 Standards								
508	800	42	NT-N1	Micrologic®	100–800	OFF[3]	Adjustable	None[5]
			NT-L1F					9,000–11,000
			NW-N1		100–250			21,600–26,400
					400–800			None[6]
		65	NW-H1		100–250			21,600–26,400
					400–800			None[5]
		85	NW-H2		100–250			21,600–26,400
					400–800			None[5]
		100	NW-H3		100–800			76,500–93,500
		200	NW-L1		100–250			21,600–26,400
					400–800			31,500–38,500
			NW-L1F		100–800			21,600–26,400

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Table 6: 480 Volt Circuit Breakers *(continued)*

Voltage Rating	Frame Size (Amperes)	Interrupting Rating (kA) 60 Hz	Circuit Breaker	Trip Unit Type	Continuous Current Range (Amperes)	Instantaneous Trip Range (Amperes)[1]	Instantaneous Trip Type	Instantaneous Selective Override Trip Range (Amperes)[2]
508	1600	42	NW-N1	Micrologic®	800–1600	OFF[3]	Adjustable	None[5]
		65	NW-H1					
		85	NW-H2					
		100	NW-H3					76,500–93,500
		200	NW-L1					31,500–38,500
			NW-L1F					21,600–26,400
	2000	65	NW-H1		1000–2000			None[5]
		85	NW-H2					
		100	NW-H3					76,500–93,500
		200	NW-L1					31,500–38,500
			NW-L1F					21,600–26,400
	3200	65	NWH1		1600–3200			None[5]
		85	NWH2					
		100	NWH3					76,500–93,500
		200	NWL1					105,300–128,700
	4000	85	NW-H2		2000–4000			None[5]
		100	NW-H3					76,500–93,500
		200	NW-L1					105,300–128,700
	5000	85	NW-H2		2500–5000			None[5]
		100	NW-H3					76,500–93,500
		200	NW-L1					105,300–128,700

1 For thermal-magnetic circuit breakers with fixed instantaneous trip, the lower number is the "must hold" and the higher number the "must trip" value. For thermal-magnetic circuit breakers with adjustable instantaneous trip, the adjustment range shown is a function of the continuous current rating (CCR, aka ampere or handle rating) of the circuit breaker. The allowable UL tolerances are -20% (low) and +30% (high) from the nominal values shown. For electronic trip circuit breakers, the adjustment range shown is a function of the rating plug (P) or the sensor (In). Tolerances are +/-10% on both the low and high end of the range.

2 The range shown reflects manufacturing tolerances.

3 Turning the instantaneous setting to OFF on Micrologic® electronic trip units will maximize short circuit selective coordination. An OFF setting is available on Micrologic® trip units with LSI or LSIG protection.

4 1200 amperes maximum in I-Line®.

5 This circuit breaker, with the instantaneous set to OFF, is fully selective up to the interrupting rating of the circuit breaker.

6 This circuit breaker, with the instantaneous set to OFF, is fully selective up to the interrupting rating of the circuit breaker.

Table 7: 600 Volt Circuit Breakers

Voltage Rating	Frame Size (Amperes)	Interrupting Rating (kA) 60 Hz	Circuit Breaker	Trip Unit Type	Continuous Current Range (Amperes)	Instantaneous Trip Range (Amperes)[1]	Instantaneous Trip Type	Instantaneous Selective Override Trip Range (Amperes)[2]
Molded Case Circuit Breakers: UL® 489 Standard								
600 Y / 347 Vac	100	18	GJL	T-M	15–40	600–1200	Fixed	None
					50–100	800–1400		
	110	14	ED		15–30	270–875		
					35–70	630–1800		
					80–125	1000–2300		
		18	EG		15–30	270–875		
					35–70	630–1800		
					80–125	1000–2300		
		25	EJ		15–30	270–875		
					35–70	630–1800		
					80–125	1000–2300		

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Table 7: 600 Volt Circuit Breakers *(continued)*

Voltage Rating	Frame Size (Amperes)	Interrupting Rating (kA) 60 Hz	Circuit Breaker	Trip Unit Type	Continuous Current Range (Amperes)	Instantaneous Trip Range (Amperes)[1]	Instantaneous Trip Type	Instantaneous Selective Override Trip Range (Amperes)[2]
600	100	14	FA	T-M	15–30	275–600	Fixed	None
					35–50	400–850		
					60–80	800–1450		
					90–100	900–1700		
		18	FH		15–30	275–600		
					35–50	400–850		
					60–80	800–1450		
					90–100	900–1700		
		100	FI		20–30	275–600		
					35–50	400–850		
					60–80	800–1450		
					90–100	900–1700		
	150	14	HD		15–30	350–750		
					35–50	400–850		
					60–90	800–1450		
					100–150	900–1700		
		18	HG		15–30	350–750		
					35–50	400–850		
					60–90	800–1450		
					100–150	900–1700		
		25	HJ		15–30	350–750		
					35–50	400–850		
					60–90	800–1450		
					100–150	900–1700		
		50	HL		15–30	350–750		
					35–50	400–850		
					60–90	800–1450		
					100–150	900–1700		
	250	14	JD		150–250	5–10 x CCR	Adjustable	
		18	JG					
		25	JJ					
		50	JL					
		100	KI		110–250			
	400	22	LA		125–400	5–10 x CCR	Adjustable	
			LA-MC		200–250	17–20 x CCR	Fixed	
					400	15–18 x CCR		
		25	LH		250–400	5–10 x CCR	Adjustable	
			LH-MC		200–250	17–20 x CCR	Fixed	
					400	15–18 x CCR		

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Table 7: 600 Volt Circuit Breakers *(continued)*

Voltage Rating	Frame Size (Amperes)	Interrupting Rating (kA) 60 Hz	Circuit Breaker	Trip Unit Type	Continuous Current Range (Amperes)	Instantaneous Trip Range (Amperes)[1]	Instantaneous Trip Type	Instantaneous Selective Override Trip Range (Amperes)[2]
600	600	18	DG	STR23SP	150–600	9 x In	Fixed	6,000
				STR53UP		1.5–7 x In	Adjustable	
		35	DJ	STR23SP		9 x In	Fixed	
				STR53UP		1.5–7 x In	Adjustable	
			LC	T-M	300–400	5 x CCR–3,200	Adjustable	None
					450–600	5 x CCR–4,200		
			LE	Micrologic®	100–600	OFF[3]		9 x P–11 x P
			LX			2.5–8 x P		
		100	LI	T-M	300–400	5 x CCR–3,200		None
					450–600	5 x CCR–4,200		
			LXI	Micrologic®	100–600	2.5–8 x P		9 x P–11 x P
	800	18	MG	ET1.01	300–800	5–10 x CCR		None
		25	MJ					
	1200	18	PG	ET1.01	600–1200	5–10 x CCR		21,600–26,400
				Micrologic®	100–1200	OFF		
		25	PJ	ET1.01	600–1200	5–10 x CCR		9,000–11,000
				Micrologic®	100–1200	OFF[3]		
		50	PK	ET1.01	600–1200	5–10 x CCR		21,600–26,400
				Micrologic®	100–1200	OFF[3]		
	2500	18	RG[4]	ET1.01	1200–2500	5–10 x CCR		51,300–62,700
				Micrologic®	240–2500	OFF[3]		
		25	RJ[4]	ET1.01	1200–2500	5–10 x CCR		43,200–52,800
				Micrologic®	240–2500	OFF[3]		
		50	RL[4]	ET1.01	1200–2500	5–10 x CCR		
				Micrologic®	240–2500	OFF[3]		
		65	RK[4]	ET1.01	1200–2500	5–10 x CCR		51,300–62,700
				Micrologic®	240–2500	OFF[3]		
Insulated Case Circuit Breakers (Masterpact®): UL® 489 Standard								
600	800-1200	35	NT-N	Micrologic®	100–1200	OFF[3]	Adjustable	36,000–44,000
		50	NT-H					
	800-2000	50	NW-N		100–2000			
		85	NW-H					
		100	NW-L		100–250			21,600–26,400
					400–1600			31,500–38,500
					2000			58,500–71,500
			NW-LF		100–2000			19,800–24,200
	2500-3000	85	NW-H		1200–3000			58,500–71,500
		100	NW-L					
	4000-6000	85	NW-H		2000–6000			67,500–82,500
		100	NW-L					

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Table 7: 600 Volt Circuit Breakers *(continued)*

Voltage Rating	Frame Size (Amperes)	Interrupting Rating (kA) 60 Hz	Circuit Breaker	Trip Unit Type	Continuous Current Range (Amperes)	Instantaneous Trip Range (Amperes)[1]	Instantaneous Trip Type	Instantaneous Selective Override Trip Range (Amperes)[2]
Low Voltage Power Circuit Breakers (Masterpact®): UL® 1066 / ANSI C37 Standards								
635	800	42	NW-N1	Micrologic®	100–250	OFF[3]	Adjustable	21,600–26,400
					400–800			None[5]
		65	NW-H1		100–250			21,600–26,400
					400–800			None[5]
		85	NW-H2		100–250			21,600–26,400
					400–800			None[5]
			NW-H3		100–800			76,500–93,500
		130	NW-L1		100–250			21,600–26,400
					400–800			31,500–38,500
			NW-L1F		100–800			21,600–26,400
	1600	42	NW-N1		800–1600			None[5]
		65	NW-H1					
		85	NW-H2					
			NW-H3					76,500–93,500
		130	NW-L1					31,500–38,500
			NW-L1F					21,600-26,400
	2000	65	NW-H1		1000–2000			None[5]
		85	NW-H2					
			NW-H3					76,500–93,500
		130	NW-L1					31,500–38,500
			NW-L1F					21,600-26,400
	3200	65	NW-H1		1600–3200			None[5]
		85	NW-H2					
			NW-H3					76,500–93,500
		130	NW-L1					105,300–128,700
	4000	85	NW-H2		2000–4000			None[5]
			NW-H3					76,500–93,500
		130	NW-L1					105,300–128,700
	5000	85	NW-H2		2500–5000			None[5]
			NW-H3					76,500–93,500
		130	NW-L1					105,300–128,700

1 For thermal-magnetic circuit breakers with fixed instantaneous trip, the lower number is the “must hold” and the higher number the “must trip” value. For thermal-magnetic circuit breakers with adjustable instantaneous trip, the adjustment range shown is a function of the continuous current rating (CCR, aka ampere or handle rating) of the circuit breaker. The allowable UL tolerances are -20% (low) and +30% (high) from the nominal values shown. For electronic trip circuit breakers, the adjustment range shown is a function of the rating plug (P) or the sensor (In). Tolerances are +/-10% on both the low and high end of the range.

2 The range shown reflects manufacturing tolerances.

3 Turning the instantaneous setting to OFF on Micrologic® electronic trip units will maximize short circuit selective coordination. An OFF setting is available on Micrologic® trip units with LSI or LSIG protection.

4 1200 amperes maximum in I-Line®.

5 This circuit breaker, with the instantaneous set to OFF, is fully selective up to the interrupting rating of the circuit breaker.

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APPENDIX—B

Glossary

ampacity The RMS current, in amperes, that a conductor or circuit breaker can carry continuously under the conditions of use without exceeding its temperature rating.

ampere rating See continuous current rating.

branch circuit The circuit between the final overcurrent device protecting the circuit and the outlet(s) or loads.

circuit breaker A device designed to open and close a circuit by non-automatic means and to open the circuit automatically on an overcurrent without damage to itself when properly applied within its rating.

circuit breaker frame (1) The circuit breaker housing which contains the current carrying components, the current sensing components, and the tripping and operating mechanism. (2) That portion of an interchangeable trip molded case circuit breaker remaining when the interchangeable trip unit is removed.

close and latch rating The maximum level of current a circuit breaker can be closed on and still have the mechanism latch in the fully closed position.

continuous current rating The designated RMS alternating or direct current in amperes which a device or assembly will carry continuously in free air without tripping or exceeding temperature limits.

current sensor A component which is able to sense the level of current flowing in a circuit breaker conductor and input a proportional signal into the trip unit of the circuit breaker.

feeder circuit A circuit between the main overcurrent-protecting device and the final branch circuit overcurrent protective devices.

frame size The largest ampere rating available in a group of circuit breakers of similar physical configuration.

ground fault An unintentional current path, through a grounded conductor, enclosure, raceway or the earth, back to the source.

handle rating See continuous current rating.

instantaneous selective override A fixed, non-adjustable, instantaneous trip function set just below a circuit breakers withstand capability.

instantaneous trip A qualifying term indicating that no delay is purposely introduced in the tripping action of the circuit breaker during short-circuit conditions.

insulated case circuit breaker (ICCB) UL Standard 489 Listed non-fused molded case circuit breakers which utilize a two-step stored energy closing mechanism, electronic trip system and optional draw-out construction.

interrupting rating The highest current at rated voltage that the circuit breaker is rated to interrupt in RMS symmetrical amperes. When the circuit breaker can be used at more than one voltage, the interrupting rating will be shown on the circuit breaker for each voltage level. The interrupting rating of a circuit breaker must be equal to or greater than the available short-circuit current at the point at which the circuit breaker is applied to the system.

making current release A fixed, non-adjustable, instantaneous trip function set just below a circuit breakers close and latch rating.

molded case circuit breaker (MCCB) A circuit breaker which is assembled as an integral unit in a supportive and enclosed housing of

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insulating material, generally 20 to 3000 A in size and used in systems up to 600 Vac and 500 Vdc.

selective coordination Localization of an overcurrent condition to restrict an outage to the circuit or equipment affected, accomplished by the choice of overcurrent protective devices and their ratings or settings.
(NEC 100 – Definitions)

zone-selective interlocking (ZSI) A communication capability between electronic trip systems and ground-fault relays which permits a short circuit or ground fault to be isolated and cleared by the nearest upstream device with no intentional time delay.

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