

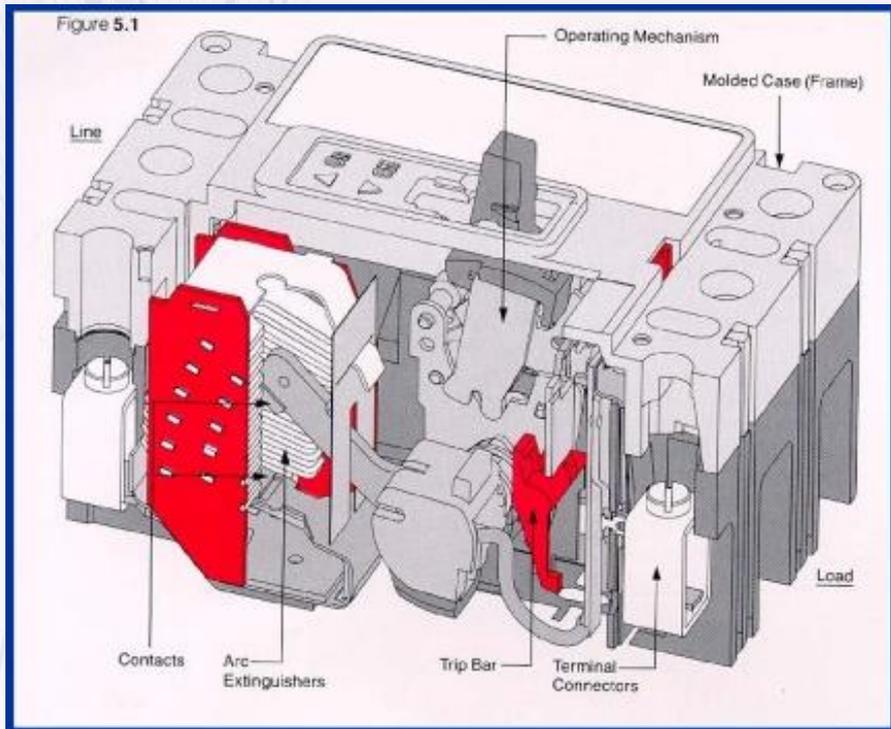
MOLDED CASE CIRCUIT BREAKER BASICS

David Castor, P.E.

History of MCCBs

- 1904 - Cutter Manufacturing Co., Philadelphia, produces *circuit breakers*. They called it the *Inverse Time Element* breaker, or I-T-E breaker and the company later became the I-T-E Co.
- 1925 - NEC- Circuit breakers required to be enclosed and externally operable.
- 1932 - Westinghouse introduces their modern molded case air circuit breaker.
- 1973 - First electronic trip unit

Basic MCCB Components



- Molded Case
- Line and Load Terminals
- Operating Mechanism
- Trip Bar
- Contacts
- Arc Extinguisher

Standards

- In the US, the primary MCCB standard is UL 489.
- UL 489 covers virtually all types of molded-case circuit breakers.
- NEC and UL 489 requirements are generally harmonized and consistent
- NEMA AB3 and AB4 are free standards on application and field inspection/testing of MCCBs.

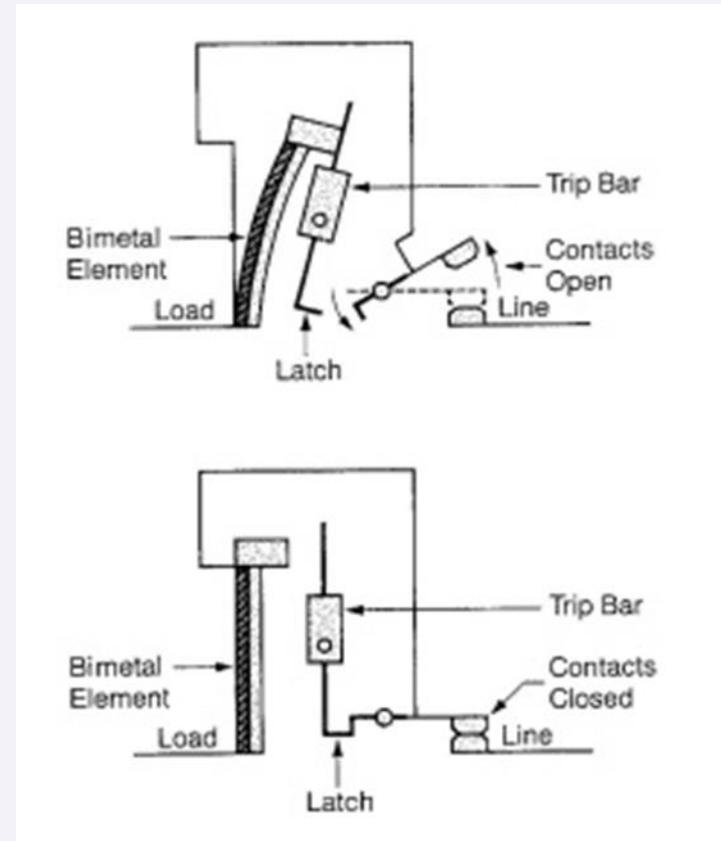
Thermal-Magnetic MCCB

- Electro-mechanical
- Two separate tripping mechanisms:
 - Thermal inverse-time element for low level faults/overloading
 - Magnetic (Instantaneous) trip for short circuits
 - Magnetic trip may be adjustable



Thermal Element

- Bimetallic Element
- Unequal thermal expansion causes element to bend
- Inverse time characteristics - higher current, more heat faster tripping.
- Protects against long-term overloads, low current faults
- Sensitive to ambient temperature



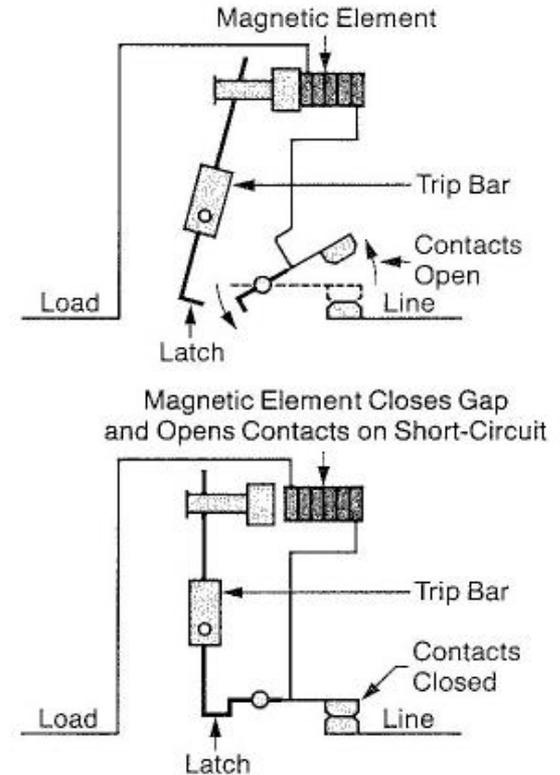
UL Requirements for Thermal Element

- Must carry 100% of rated current continuously at 40 deg C ambient **IN OPEN AIR.**
- At 200% rated current, maximum trip times are given based on breaker size:

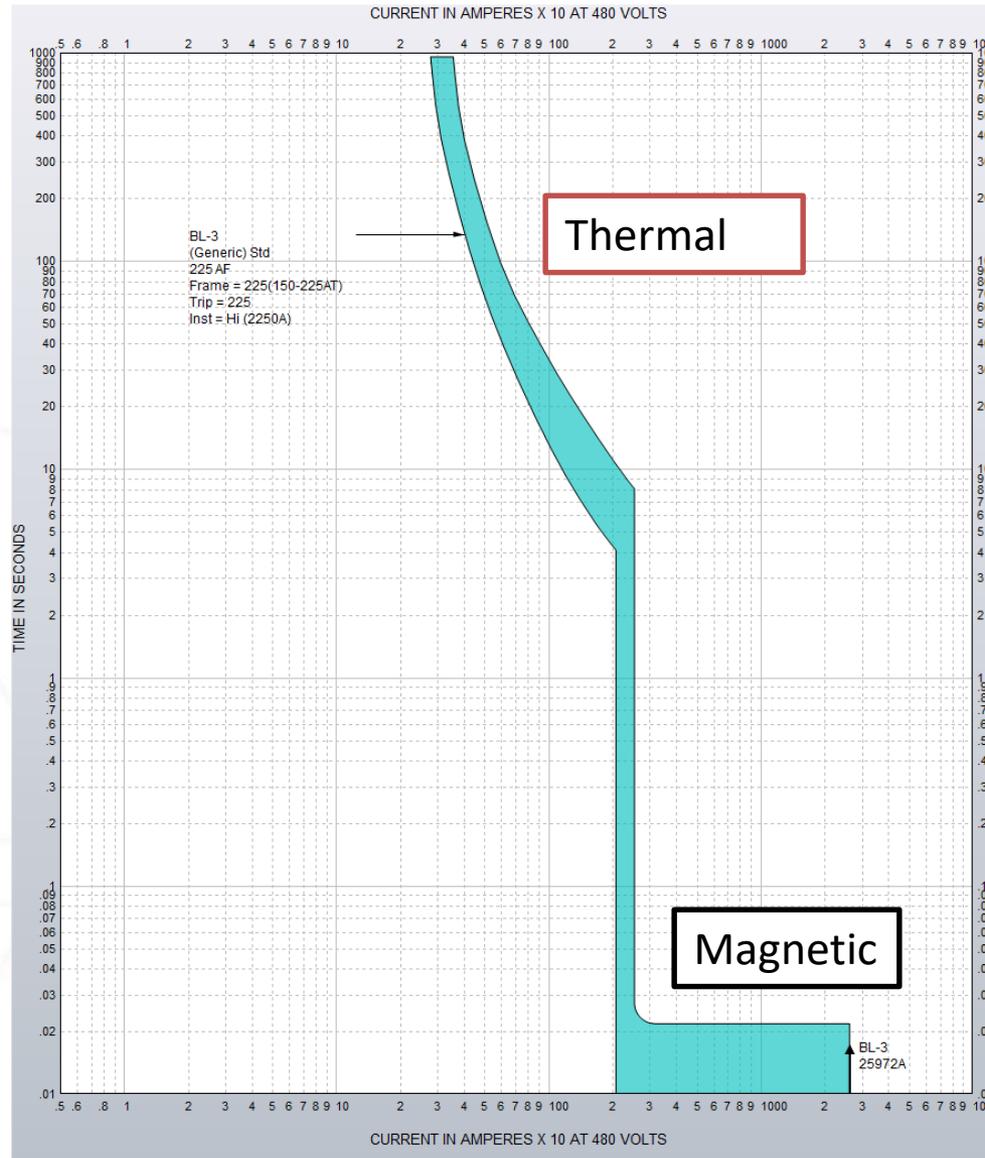
Amp Rating	Max Time @ 200%
0-30	2 min
31-50	4 min
51-100	6 min
101-150	8 min
151-225	10 min
.	
.	
1601-2000	28 min

Magnetic Trip

- Electro-magnet in series with current.
- Designed to trip above a certain current with no intentional delay.
- Detects short circuit current
- Adjustable in larger breaker sizes
- Generally will respond to peak asymmetrical current
- 1.5 cycle fault clearing or less
- Magnetic trip is why arc-flash levels tend to be low when protected by MCCB.
- MCCB must have instantaneous trip per UL489.
- Can create mis-coordination for MCCBs in series



Typical Thermal-Magnetic TCC



“Generic” MCCBs in EasyPower

LV Breaker Data

Connection Information

ID Name: BL-1 Open Closed

On Bus = MAIN SWBD Base kV: 0.48

Connection Type = Feeder Lock Auto-Sizing Lock Auto-Coordination

Specifications Short Circuit Phase Trip Gnd Trip ZSI Fuse Mtr O/L Harmonics Stability Comments

Class LVPCB ICQB MCCB

Breaker Mfr: (Generic) Breaker Type: Std Breaker Style: 400 AF End Style

Frame (400 A)

Fused Breaker Breaker Contactor

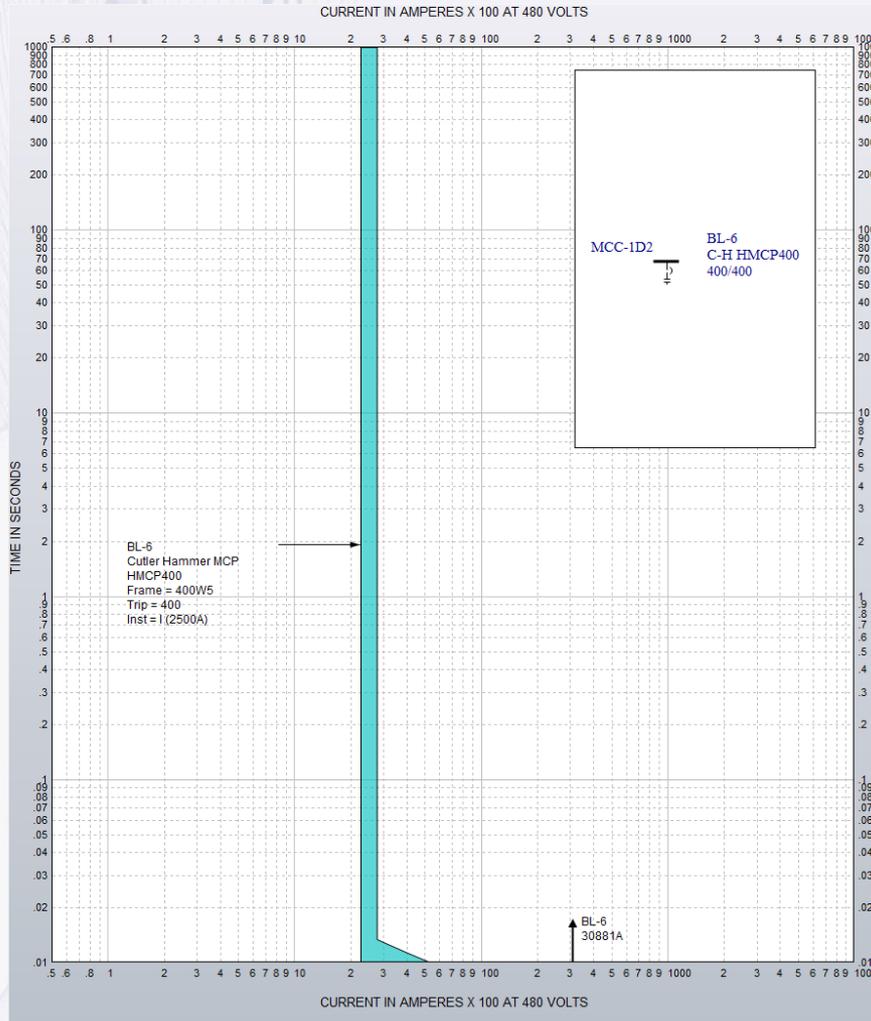
Type: Style:

Plug:

OK Cancel Help

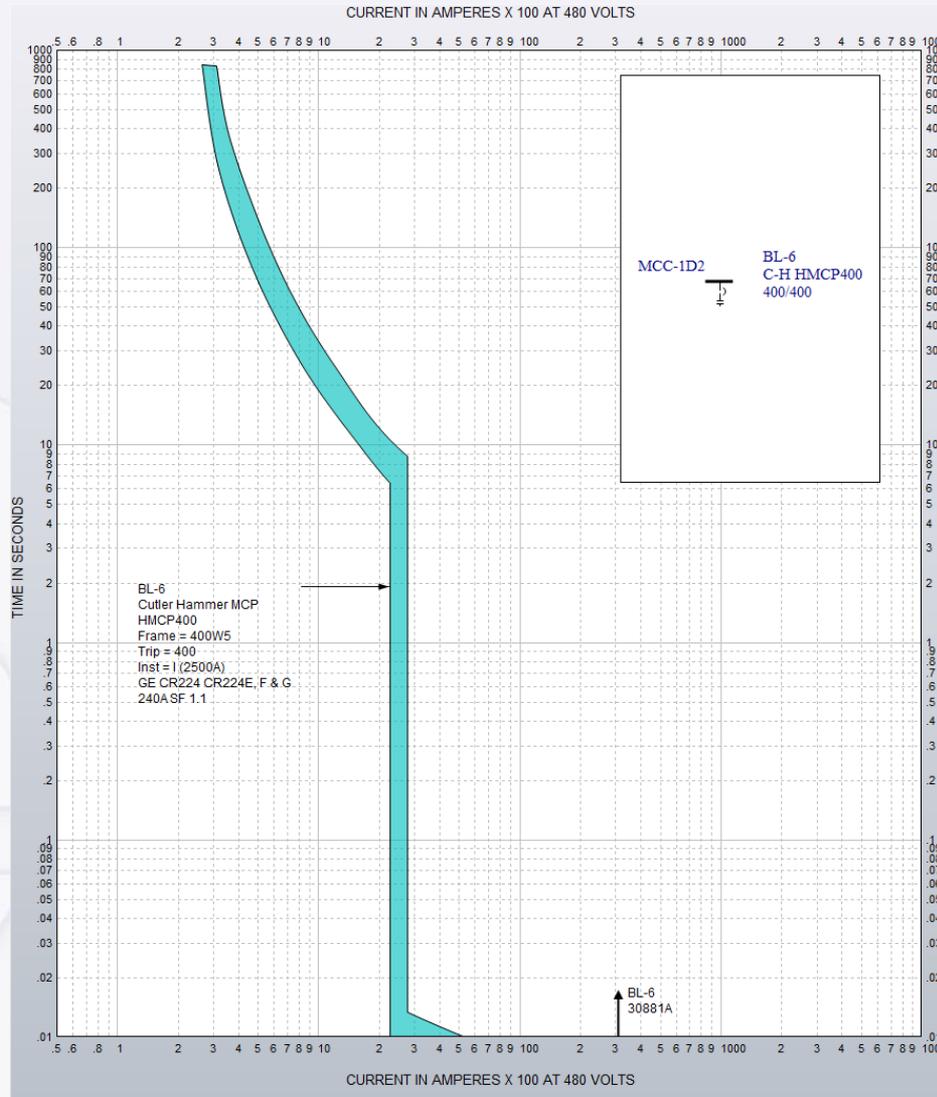
- Provide typical thermal-magnetic TCCs for MCCBs up through 1200 A.
- TCCs consistent with UL 489 tripping requirements and IEEE 1584.
- Use in design phase or when exact breaker type is not known.
- Should be conservative
- A “Generic” design sheet is also provided in Auto Design.

Motor Circuit Protectors (MCPs)



- MCCB with NO THERMAL element.
- “Magnetic-only”
- Can ONLY be used as part of a listed combination motor starter. Overload relay provides the thermal protection
- Cannot use as a feeder breaker.
- In EasyPower treated as “thermal-magnetic”

MCP + Overload Relay



Motor OL Defined with Bkr Data

Temporary Thermal Magnetic Data

Connection Information

ID Name: Open Closed

On Bus = MCC-1D2 Base kV:

Connection Type = Feeder Lock Auto-Sizing Lock Auto-Coordination

Specifications Short Circuit Phase Trip ZSI Fuse Mtr O/L Stability

Plot Motor Overload Relay TCC

Motor Overload Relay

Mfr: Type: Style:

Motor Parameters

FLA:

Service:

Advantages of MCPs

- Special application allows wider range of sizes and trip adjustments than standard thermal-magnetic breakers
- Specially-designed trip coils with some transient suppression
- Faster tripping for typical motor faults than fuses.

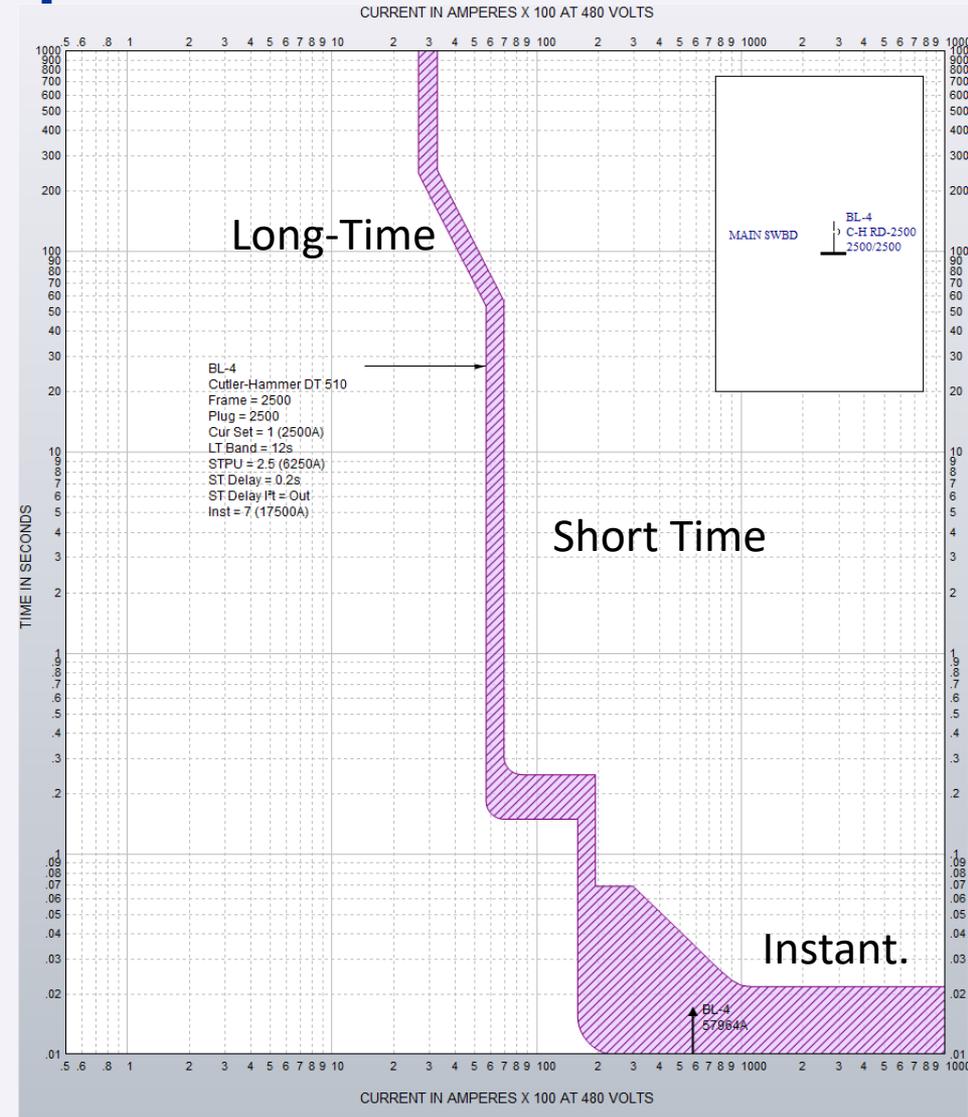
Solid-State Trip Units

- Electronic (now all digital) current sensing replaces thermal and magnetic trip elements.
- Trip mechanism and arc-extinguishing same as thermal-magnetic
- More accurate and more flexible settings
- Instantaneous still required.
- Ground fault easy to provide
- Becoming standard for larger size breakers
- Required for 100%-rated breakers.



Typical TCC for Large MCCB w/SS Trip

- Long-time pickup (may be fixed w/rating plug)
- Long-time delay
- Short-time trip
- Instantaneous trip
- Ground trip
- Metering functions
- Communications



MCCB Maintenance & Testing

- Can be difficult to tell when MCCB needs replacing.
- No user serviceable parts - opening case voids warranty.
- Thermography has proven useful to get some assessment of breaker condition.
- UL489 type testing requires two fault interruptions at the breaker max fault rating.
- IEEE 1458 covers life expectancy and field testing of MCCBs. (Not free!)
- Arc-Flash calculations assume all breakers will function within published TCC.

NEMA AB4 Covers MCCB Field Inspection and PM



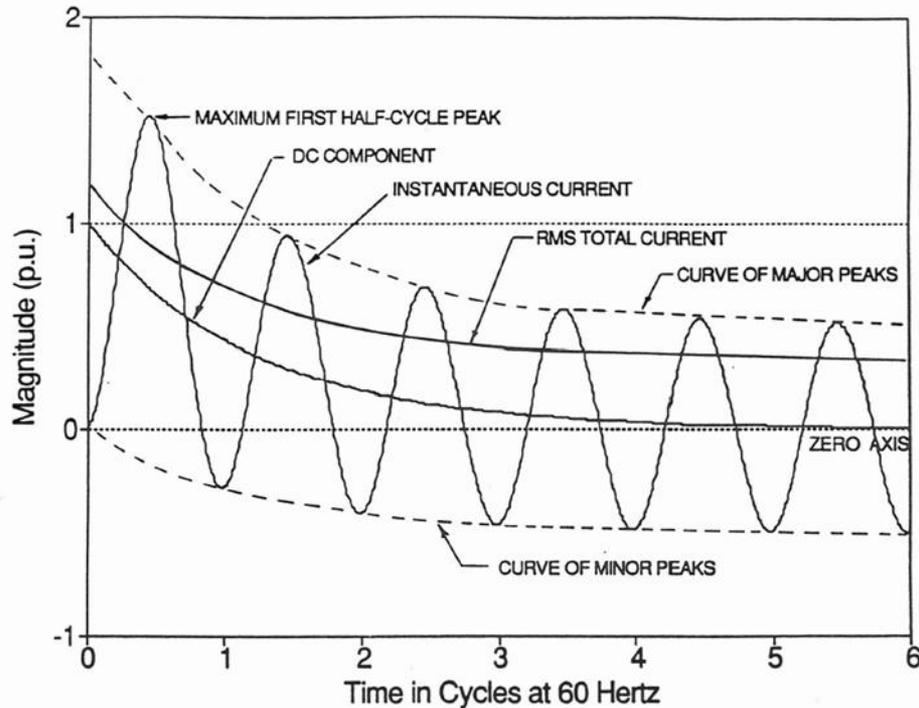
- Free standard
- Replace not Repair

MCCB Interrupting Ratings

- MCCB have a single short circuit rating, stated in rms symmetrical amps using $\frac{1}{2}$ cycle network.
- However, breaker testing is done at a specific power factor. If your system's X/R exceeds the test value, the breaker must be de-rated.
- This is done automatically using SmartDuty.

Interrupting Rating	Test Power Factor	Equivalent X/R
10 kA and below	0.5	1.7
>10 kA<20 kA	0.3	3.2
20 kA and above	0.2	4.9

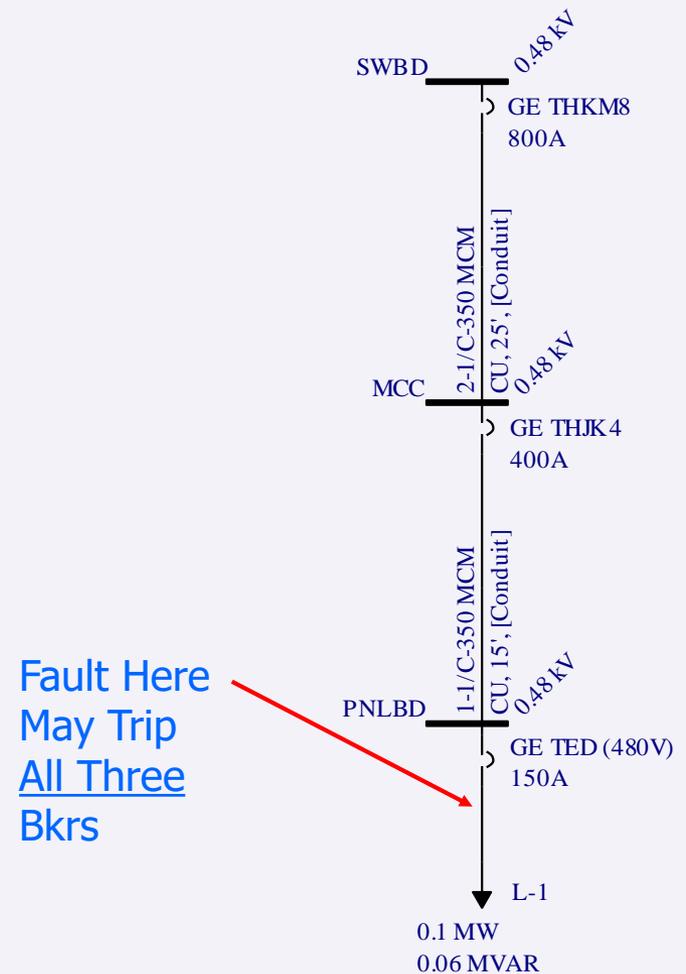
X/R Ratio Key Factor in Breaker Ratings



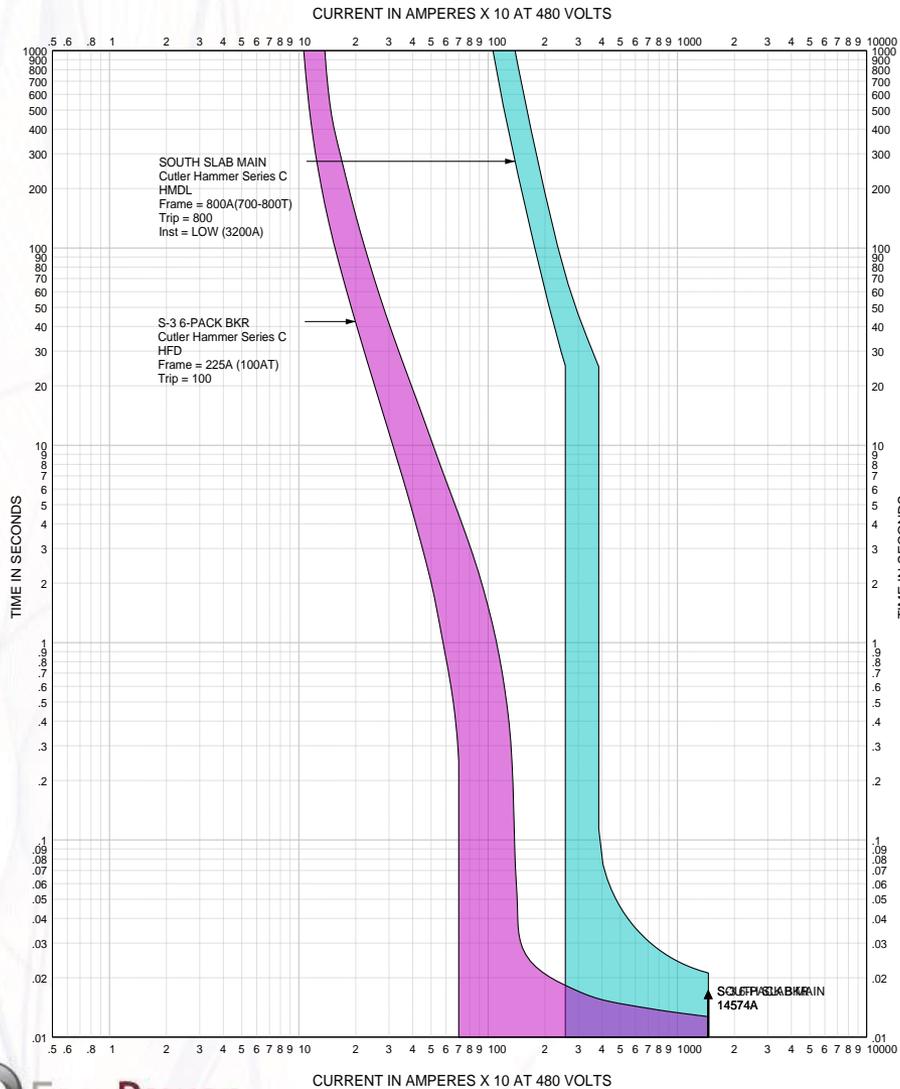
- Even for breakers rated on a symmetrical basis, peak current is still the critical value
- If system X/R exceeds test X/R, breaker must be de-rated.
- De-rating is done by **INCREASING** the DUTY amps

Coordination Between MCCBs

- General case - do not coordinate
- May coordinate below certain levels of fault current if the maximum fault current is less than the instantaneous pickup of the upstream breaker



MCCBs in Series



NEC Does Not Require Selective Coordination Except for Emergency Power Systems

MCCB manufacturers now testing for *series coordination* between breakers to compete with fuses on selective coordination

Series Coordination of MCCBs:

- Valid only by test
- Test data shows MCCBs will coordinate even though curves overlap on TCC
- Limited to same manufacturer
- Valid up to a maximum fault current
- Tracked in EasyPower Library Data

NOTE: Do not confuse “Series Coordination” with “Series Rating”. These are two different concepts.

MCCB Series Ratings

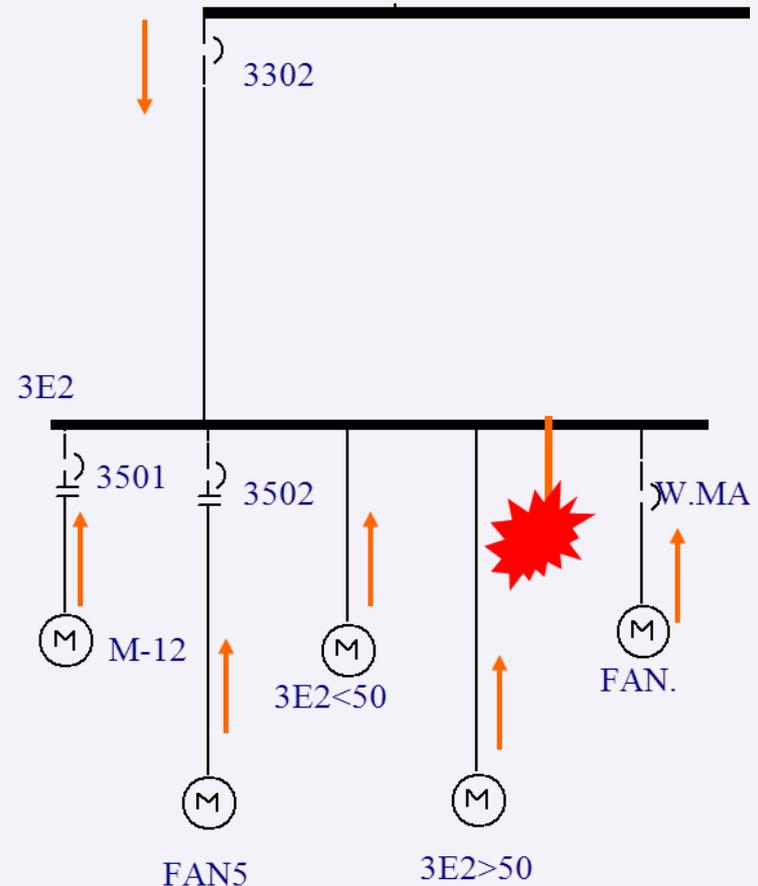
- Conservative approach: All breakers rated for maximum I_{sc} at their location. (Sleep well)
- But, when interrupting faults, MCCBs do have a “dynamic impedance” that is ignored in fault calcs. This reduces fault current to downstream breakers.
- With proper testing, MCCBs can have a higher interrupting rating when there is another MCCB upstream that will see the same fault.
- Must be tested combination - so must be same manufacturer.
- Will not coordinate for high levels for fault current
- Covered in EasyPower library data

Use of Series Ratings

- Intended for smaller distribution panels and circuits where loads are primarily branch circuits (lighting, receptacles, etc)
- Cannot safely apply series ratings if there are substantial downstream motor loads.
- EasyPower defaults to fully rated - series rated must be selected.

Motor Contribution Problem

- Motor contributions may not be seen by the upstream device that is the basis for the series rating.
- Series rating cannot be used in this case.



100% Rated MCCBs

- Standard MCCBs rated for 100% current continuously in OPEN AIR.
- In an enclosure, they are generally limited to 80% continuous current
- Continuous is defined as 3 hours
- This is the basis of the NEC load calcs using 125% of continuous load ($1 / 1.25 = 0.8$)

Limitations of 100%-Rated MCCBs

- 100% Rating requires minimum enclosure size to limit heating
- Requires electronic trip unit
- Requires 90 deg C insulation applied at 75 deg C ampacity
- Not always an option
- More prevalent for larger breakers.

Eaton
Industrial
Circuit Breaker Frame

L630E-C

630 A max. (I_n) IEC

600 A max. (I_n) UL/CSA
630 A trip unit not UL/CSA listed.
Cat. LGE3630NNWC 3 Pole
Style 69D4630G07

Use Only With Electronic Trip Unit.

Suitable For Use On Single Phase ~ AC Circuits.
For 100% Application -

- Minimum Enclosure Size Is 28 H x 19 W x 8 D Inches.
- Use Only 90°C Wire With Ampacity Based On 75°C Rated Conductors.
- Use CU ONLY or AL3CU Terminals Only.

Terminal Cat. No.	Wire Size AWG/MCM	(mm ²)	Torque Lb-in (N-m)
CU/AL			
TAG31L	500-750	(240-380)	550 (62)
TAG32L	2-500 [2]	(35-240) [2]	375 (42)
TA350L	2-500	(35-240)	375 (42)
CU ONLY			
T631L	500-750	(240-380)	550 (62)
T632L	2-500 [2]	(35-240) [2]	375 (42)
T350L	2-500	(35-240)	375 (42)

L630E-C Interrupting Capacity
RMS Sym. Ampere

IEC 60947-2

CE

U_e	I_{cu} kA	I_{cs} kA
240 ~	65	65
415 ~	35	35
690 ~	12	9

U_{imp} 8 kV Category A

Volt	kA	NEMA Ratings
240 ~	65	
480 ~	35	
600 ~	18	

~ = 50/60 Hz

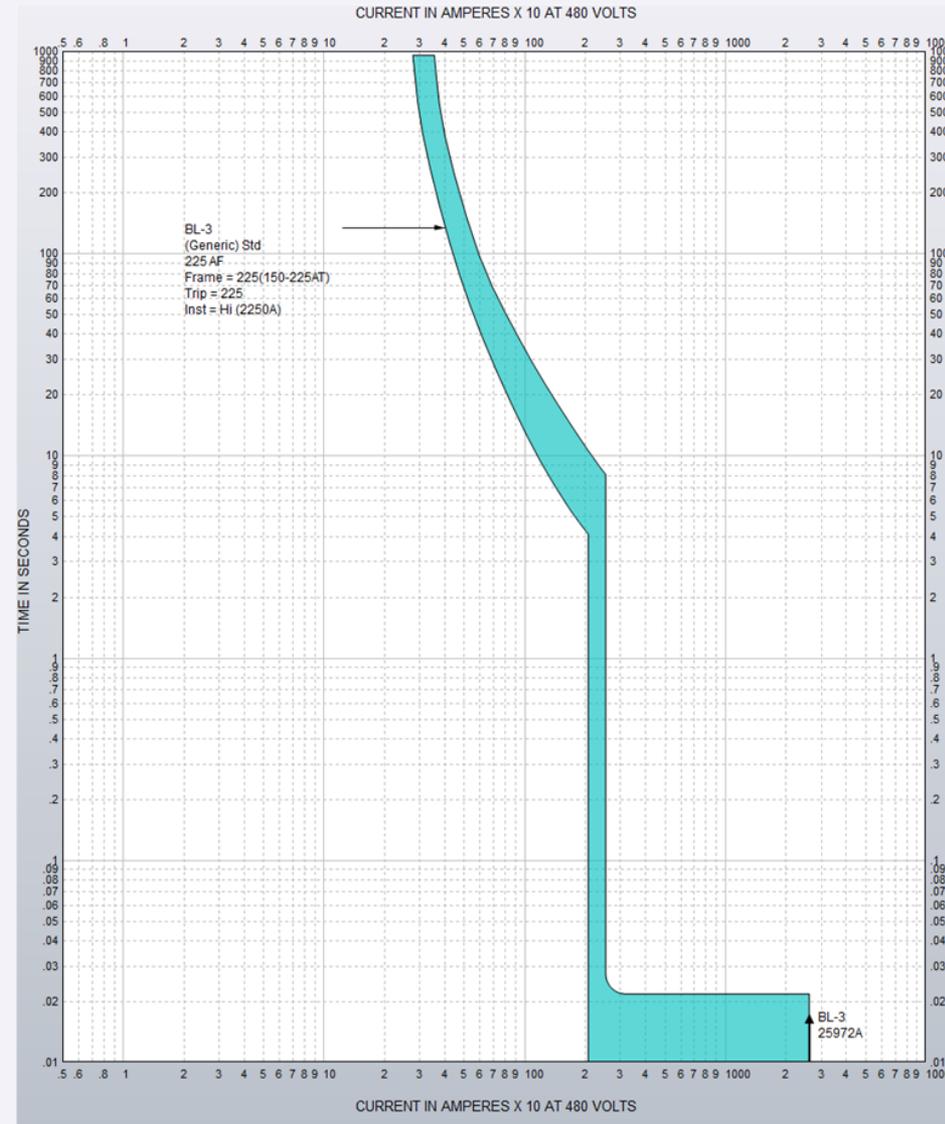
68C 4630 H50

Modification Code

Made in U.S.A.

MCCBs and Arc-Flash

- For buses protected by MCCBs:
 - If arcing fault is cleared on magnetic trip, incident energy will be low - but coordination may be poor
 - If cleared by thermal element, incident energy will be HIGH
 - This assumes the breaker will actually trip!

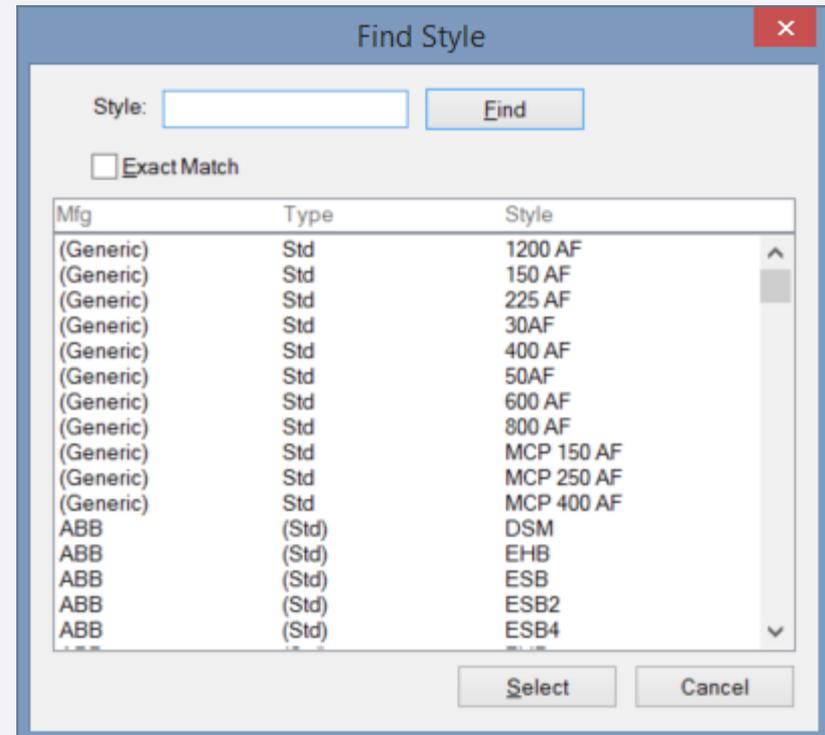


Arc-Flash Example

- Let's look at a quick example in EasyPower
- We'll see how **MORE** fault current is better than **LESS** fault current when protected by a molded case circuit breaker.

MCCB Modeling in EasyPower

- Library Data is based on manufacturer data
- TCC range varies
- Lots of breakers with similar names - must get exact match
- Use Find Style whenever possible
- Generic TCCs are OK for Arc Flash calcs if actual data not available.



MCCBs in EasyPower Library

- Separate library entries for ANSI/UL and IEC rated devices.
- If you find an MCCB that is not in the library, send data to Tech Support and we will add it to the library at no cost - for all customers on maintenance.

Questions?

- Please e-mail any additional questions to nicole@easypower.com

Thank you!