Circuit Breaker Interrupting Capacity and Short-Time Current Ratings

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Low Voltage Circuit Breakers

IEEE Definition:

A device designed to open and close a circuit by non-automatic means, and to open the circuit automatically on a predetermined overload of current without injury to itself when properly applied within its ratings

Low Voltage Circuit Breaker Types

Molded Case Circuit Breakers

- Tested in accordance with UL489
- Open Air Test - Rated @ 80%
- Over Toggle Mechanism
- Sealed Case - Not Maintainable
- Applied in Switchboards and Panelboards

Insulated Case Circuit Breakers

- Tested in accordance with UL489
- Open Air Test - Rated @ 80% or 100%
- 2-Step Stored Energy Mechanism
- Not Fully Maintainable
- Applied As Mains in Switchboards and MCCs

Power Circuit Breakers

- Tested in accordance with UL1066
- Tested in the Enclosure - Rated @ 100%
- 2-Step Stored Energy Mechanism
- Fully Maintainable
- Metal-Enclosed Draw-out Switchgear

Molded Case Circuit Breakers
Insulated Case Circuit Breakers

NEMA AB-1 – *Molded Case Circuit Breakers and Molded Case Switches*

UL489 – *Molded-Case Circuit Breakers and Circuit-Breaker Enclosures*

Low Voltage Power Circuit Breakers

ANSI C37.13 – *IEEE Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures*

ANSI C37.16 – *Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors - Preferred Ratings, Related Requirements, and Application Recommendations*

UL1066 – *Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures*

Interrupting Capacity

The Maximum Short Circuit Current that the Circuit Breaker Can Safely Interrupt at a Specific Voltage

- Expressed in rms symmetrical amperes
- Specified by current magnitude

Interrupting Capacity

The interrupting capacity for a circuit breaker provided with instantaneous trip elements is the maximum rating of the device with no intentional delay

The interrupting capacity for a circuit breaker provided without instantaneous trip elements is the maximum rating of the device for the rated time interval

Short-time Current Rating

Defines the Ability of the Device to Remain Closed for a Time Interval Under High Fault Current Conditions

- Performance of a circuit breaker over a specific current range for a period of time
- Specified by current magnitude and time magnitude
- Allows system selectivity

Low Voltage Circuit Breaker Types

Molded Case Circuit Breaker (MCCB)

- Tested in accordance with NEMA AB-1 and UL489

Insulated Case Circuit Breaker (ICCB)

- Tested in accordance with NEMA AB-1 and UL489

Power Circuit Breaker (PCB)

- Tested in accordance with ANSI C37.13 and UL1066

Instantaneous Trip Functions

- *All MCCBs and ICCBs are provided with instantaneous trip functions (no intentional delay)*
- *PCBs can be provided with or without instantaneous trip functions*

Vintage Low Voltage Circuit Breaker Trip Units

Thermal-magnetic trip elements

- Thermal element provided overload protection
- Magnetic (instantaneous) trip elements provided protection for high-magnitude faults
- Available in both MCCBs and PCBs

Thermal elements only (for PCBs)

- Thermal element provided overload protection
- 30 cycle short-time current rating
- No magnetic (instantaneous) trip elements provided
- Interrupting rating was equal to the rating with magnetic elements
- Must be applied within their short-time rating

Newer Low Voltage Circuit Breaker Trip Units

Solid-state trip elements or microprocessor-based trip elements

- Long-time pickup and delay
- Short-time pickup and delay
- Instantaneous pickup
- Ground-fault pickup and delay

Instantaneous Pick-up

- Always provided in a molded case circuit breaker or an insulated case circuit breaker
- Sometimes called magnetic pick-up
- Instantaneous override
- Optional for power circuit breakers

Short-time Current Rating

Limited to the magnetic (instantaneous) pickup level of the device

- ***MCCBs –*** limited ratings which do not usually increase with higher interrupting capacity
- ***ICCBs –*** some extended ratings
- ***PCBs –*** highest extended ratings

ANSI C37 Test Standard

Low Voltage Power Circuit Breakers -

- **Interrupting Rating:** Shall safely interrupt a rated fault current expressed in rms symmetrical amperes as measured 1/2 cycle after short circuit initiation

- **Short-Time Current Rating:** Shall remain closed during a short delay fault test of 30 cycle duration - a 15 second zero current interval - followed by another 30 cycle fault duration

All ANSI C37 Tests are Performed at 15% Power Factor, or X/R Ratio of 6.6 or Less

Interrupting Capacity

MCCBs and ICCBs

- Highest interrupting capacity
- Trips immediately for faults exceeding instantaneous pickup
- Do not need to withstand high current for an extended time delay
- Economic advantages

PCBs

- High interrupting capacity available
- Highest extended short-time current ratings

Typical 400-Ampere Frame Molded-Case Circuit Breakers[a]

MCCB Design	Low IC	High IC
Interrupting Capacity (kA @ 480 V)	35	100
Maximum Mag. Adjustment (kA)	4	4
Instantaneous Override (kA)	5	5

[a]The minimum frame size for most ICCBs and LVPCBs is 800 amperes.

Typical 800-Ampere Frame Circuit Breakers

Type of Device	MCCBs		ICCBs			LVPCBs				
	Low IC	High IC	Low IC	High IC	CL	Low IC (Internal Inst. Trip)	High IC (Internal Inst. Trip)	CL (Internal Inst. Trip)	Low IC (No Inst. Trip)	High IC (No Inst. Trip)
Interrupting Capacity (kA @ 480 V)	50	100	50	150	150	30	100	200	30	85
Instantaneous Override or Max. Short-time Current Rating (kA)	6 – 9	6 – 9	25	25	30	30	85	30	30	85
Short-time Delay (cycles)	18	18	30	30	30	30	30	30	30	30

Typical 1600-Ampere Frame Circuit Breakers

Type of Device	MCCBs		ICCBs			LVPCBs				
	Low IC	High IC	Low IC	High IC	CL	Low IC (Internal Inst. Trip)	High IC (Internal Inst. Trip)	CL (Internal Inst. Trip)	Low IC (No Inst. Trip)	High IC (No Inst. Trip)
Interrupting Capacity (kA @ 480 V)	65	100	65	150	150	50	100	200	42	85
Instantaneous Override or Max. Short-time Current Rating (kA)	17	17	35	51	30	42	85	30	42	85
Short-time Delay (cycles)	18	18	30	30	30	30	30	30	30	30

Instantaneous Settings Adjustable versus Fixed

Externally adjustable designs

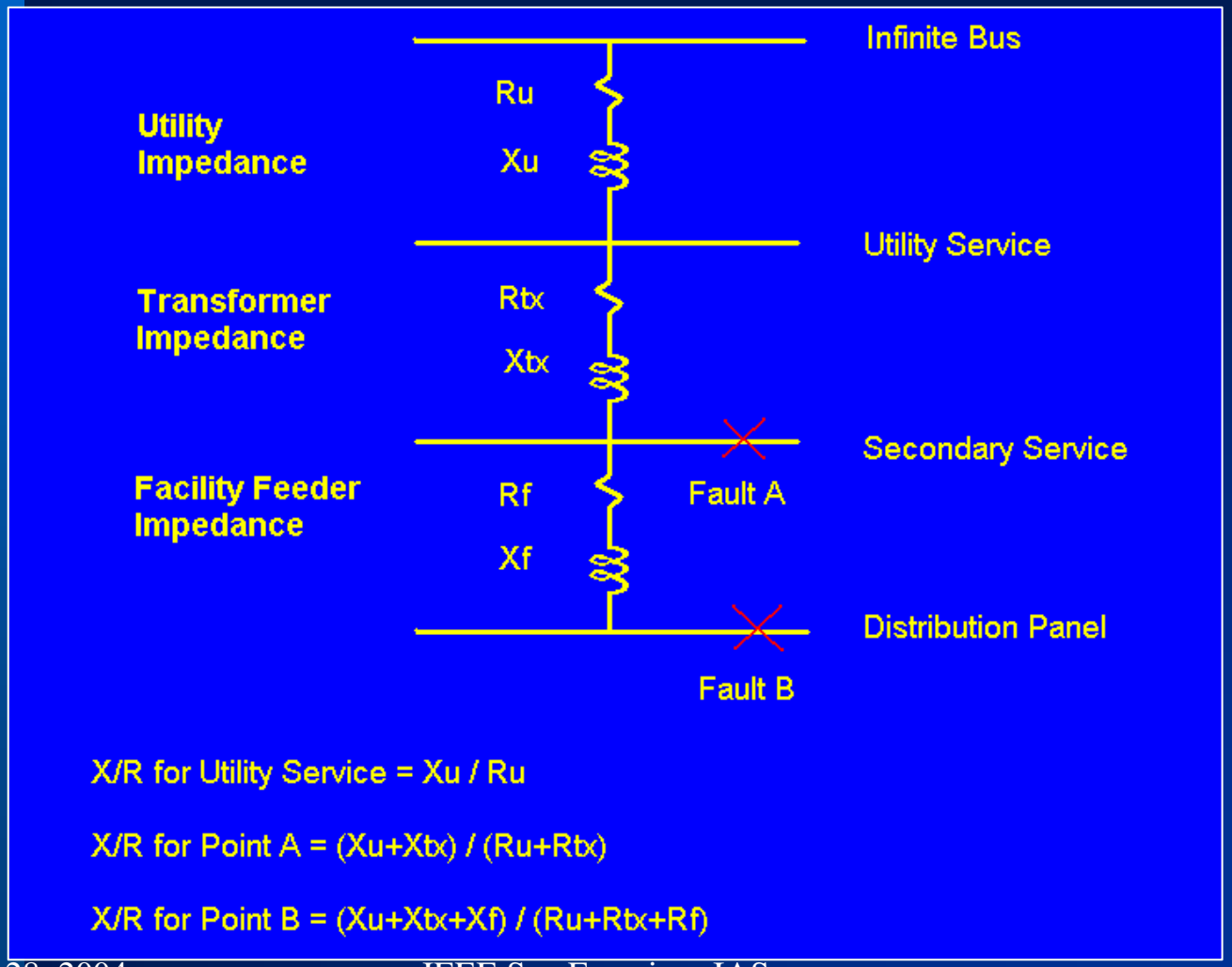
- Typical adjustment range of 5 – 10 times the frame continuous ampere rating
- Inhibits the use of a higher instantaneous pickup that may be available

Internally fixed designs

- MCCBs set at about 13 times the frame rating
- ICCB setting may be higher
- May be deleted for PCBs

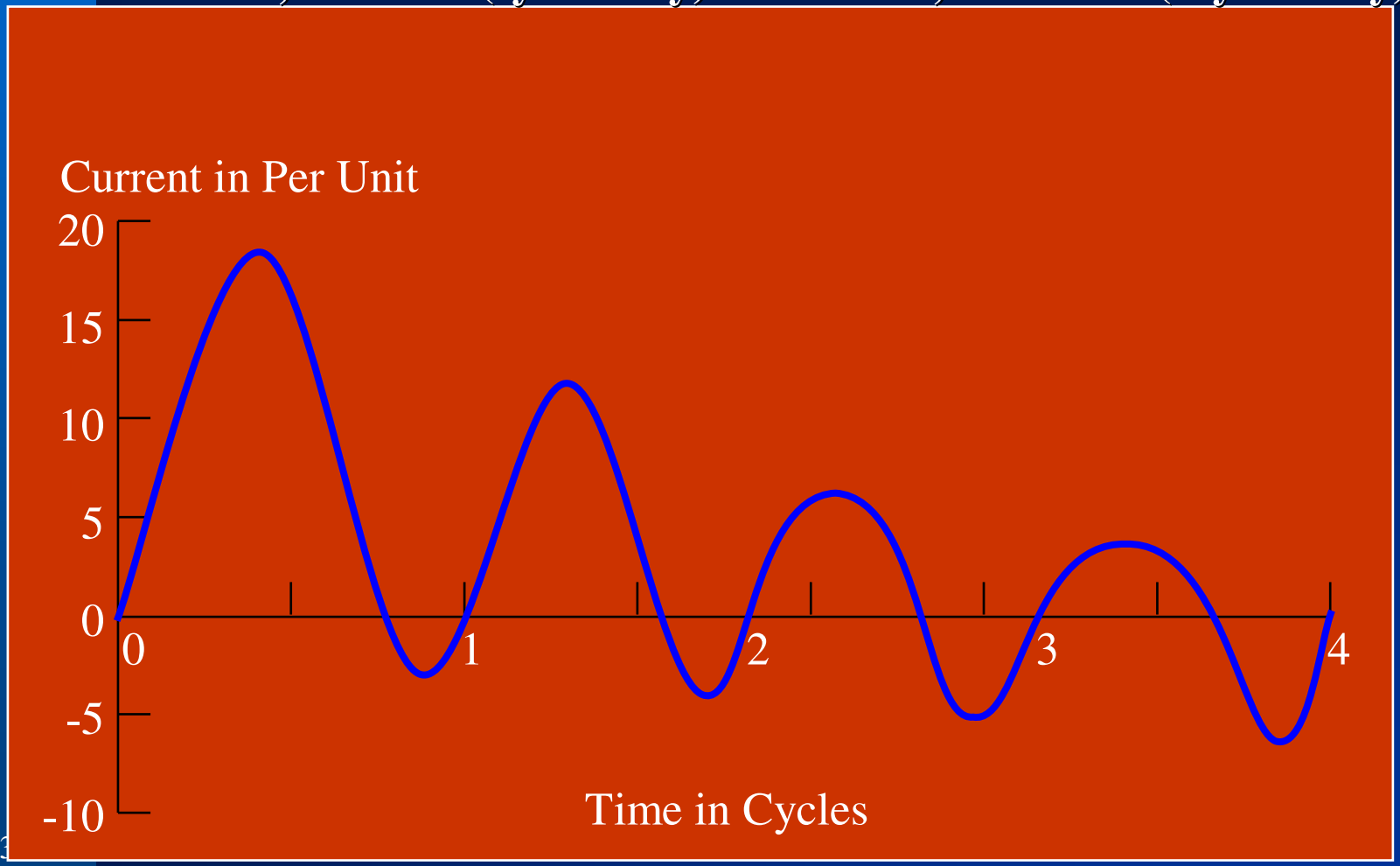
Both externally adjustable and internally fixed instantaneous trip elements inhibit the use of short-time current ratings

X/R Ratio - Impedance Diagram

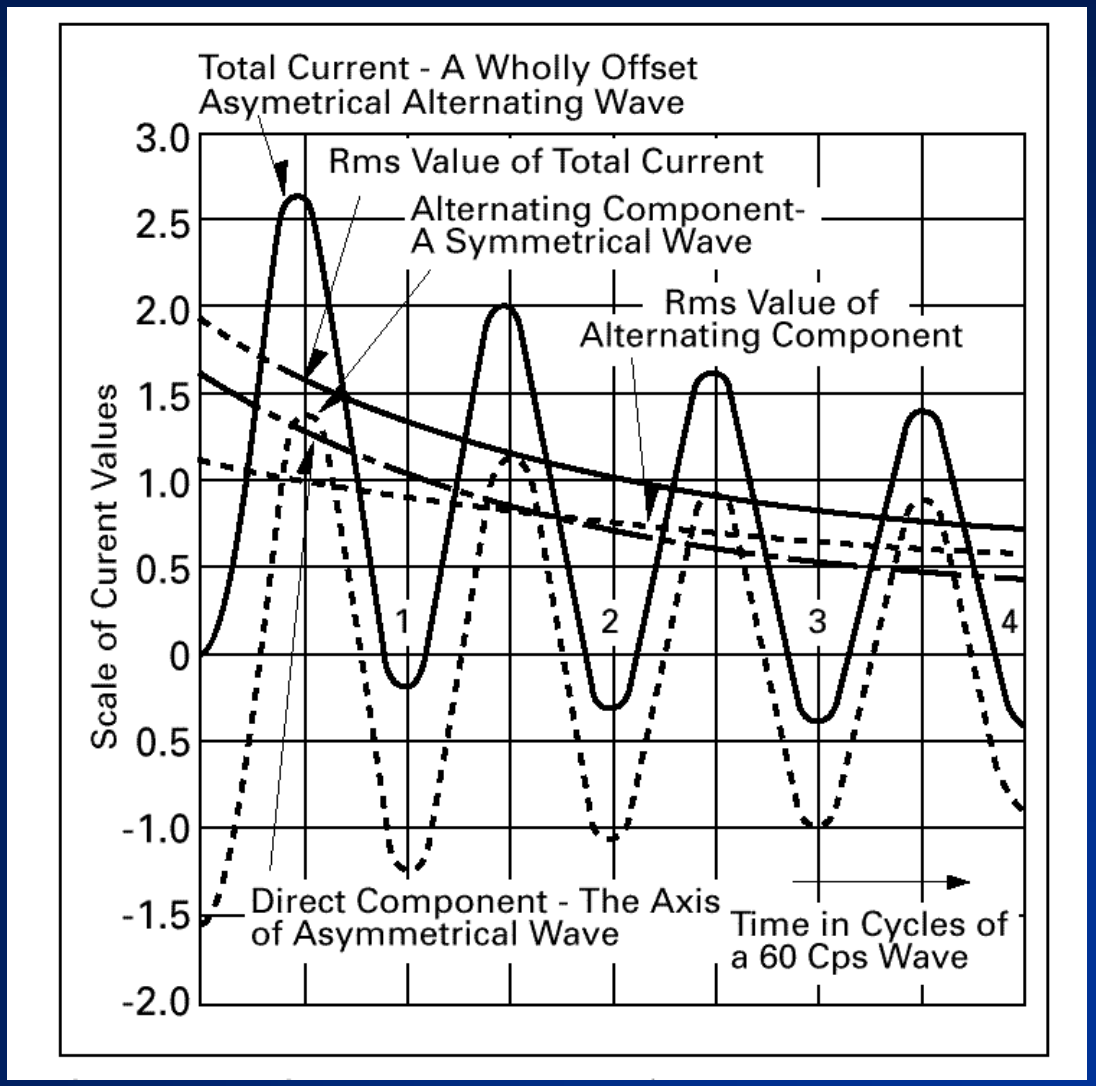


X/R Ratio Effect on Symmetry

X/R = 0, PF = 1.0 (symmetry) X/R = 6.6, PF = 0.15 (asymmetry)



Asymmetrical Current Wave

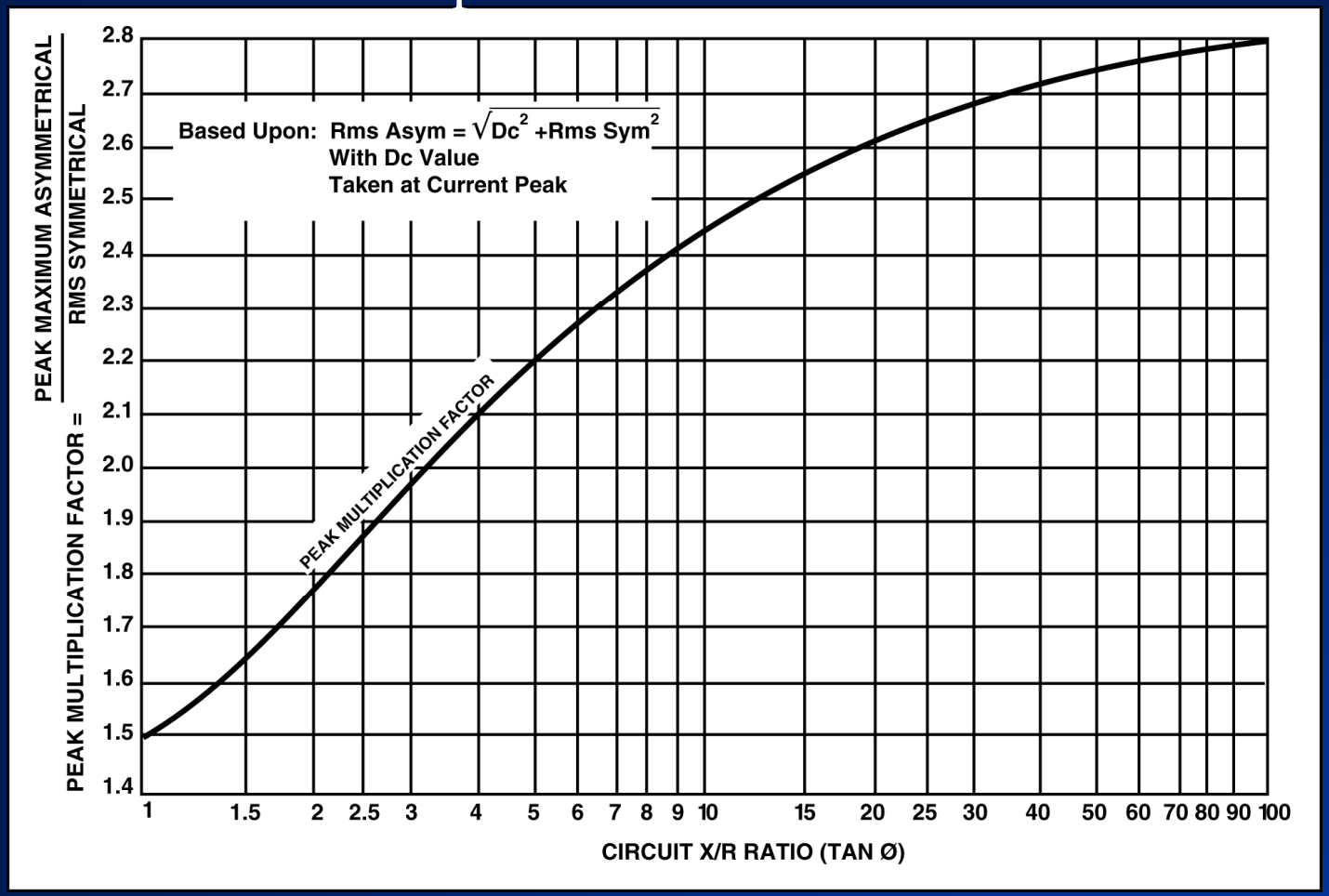


Circuit Breaker Asymmetrical Ratings

Type of Device	MCCB	ICCB	LVPCB
Test PF (%)	20	20	15
X/R	4.9	4.9	6.6
Peak Mult. Factor	2.2	2.2	2.3

X/R Ratio - Application Data

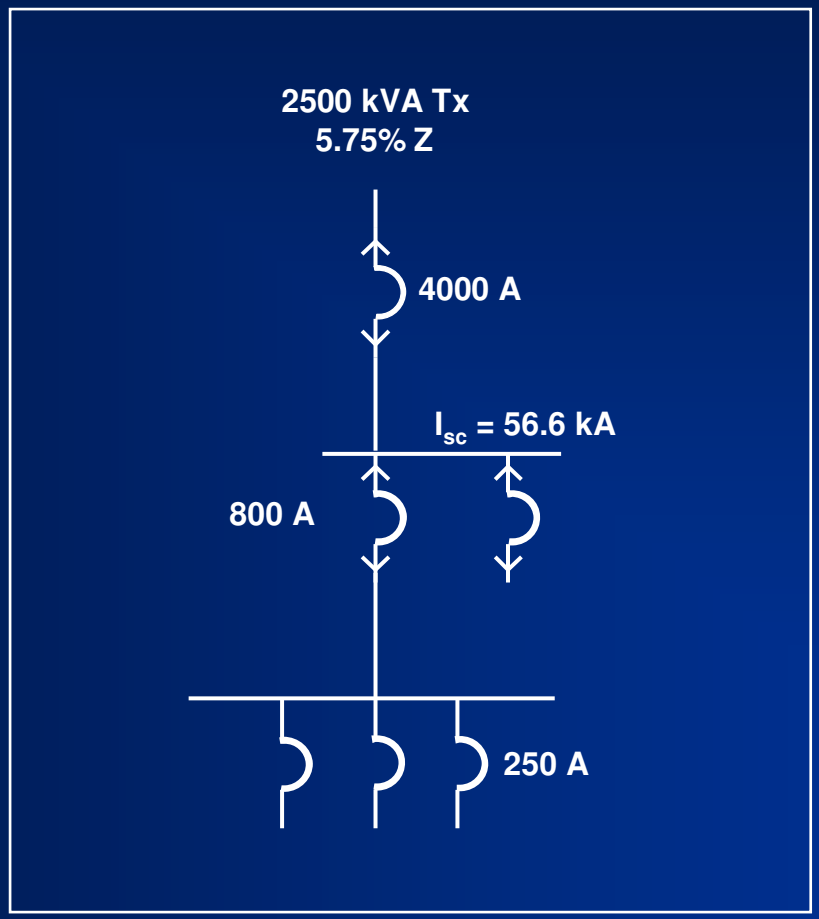
Peak Multiplication Factor



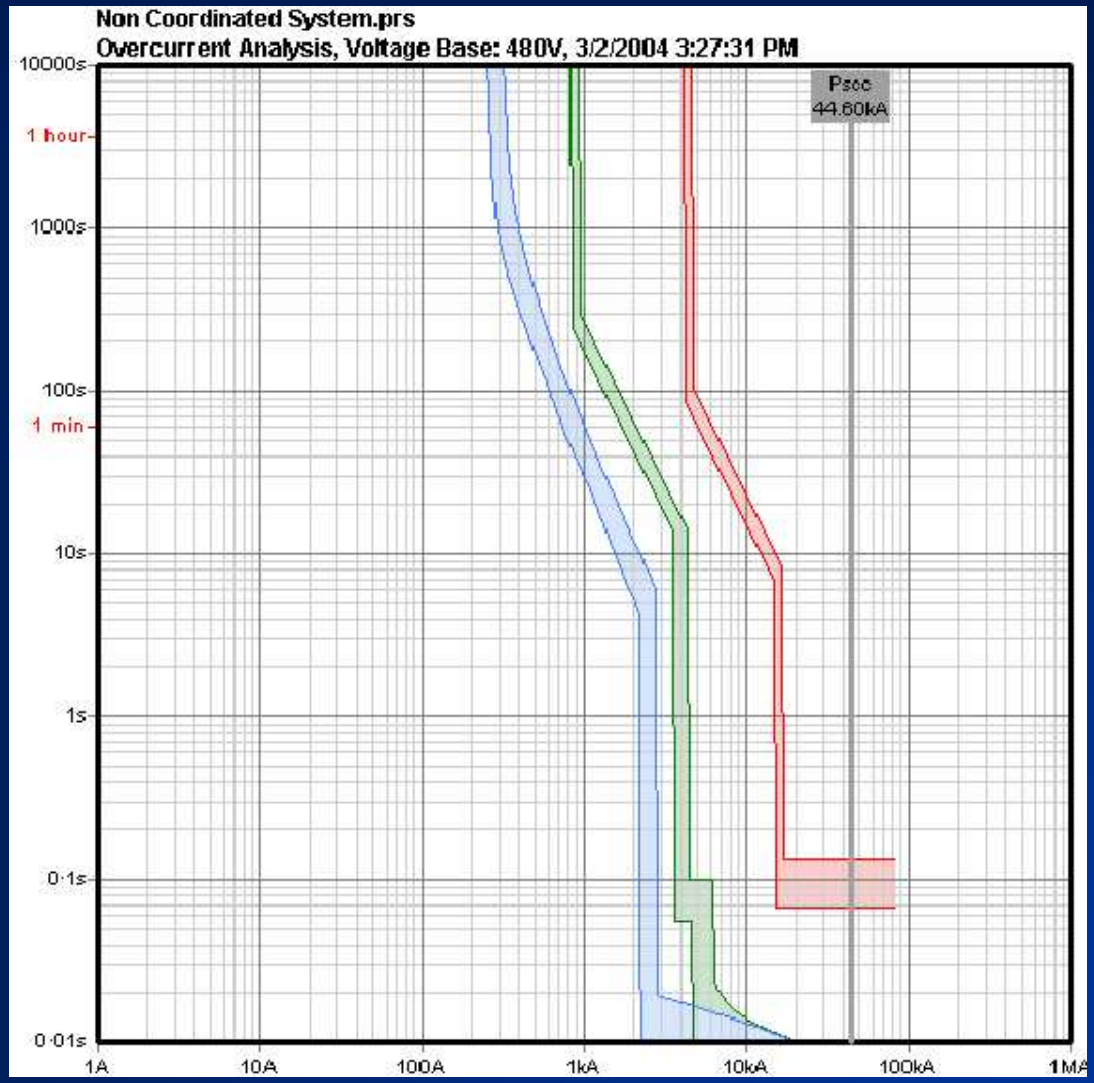
Equipment Protection Considerations

- Protection and coordination are often competing objectives
- Selective tripping is necessary for continuity of service
- Coordination is achieved through the use of short-time current ratings
- Selective coordination may be sacrificed with:
  Series ratings – instantaneous trips
  Current limiting circuit breakers

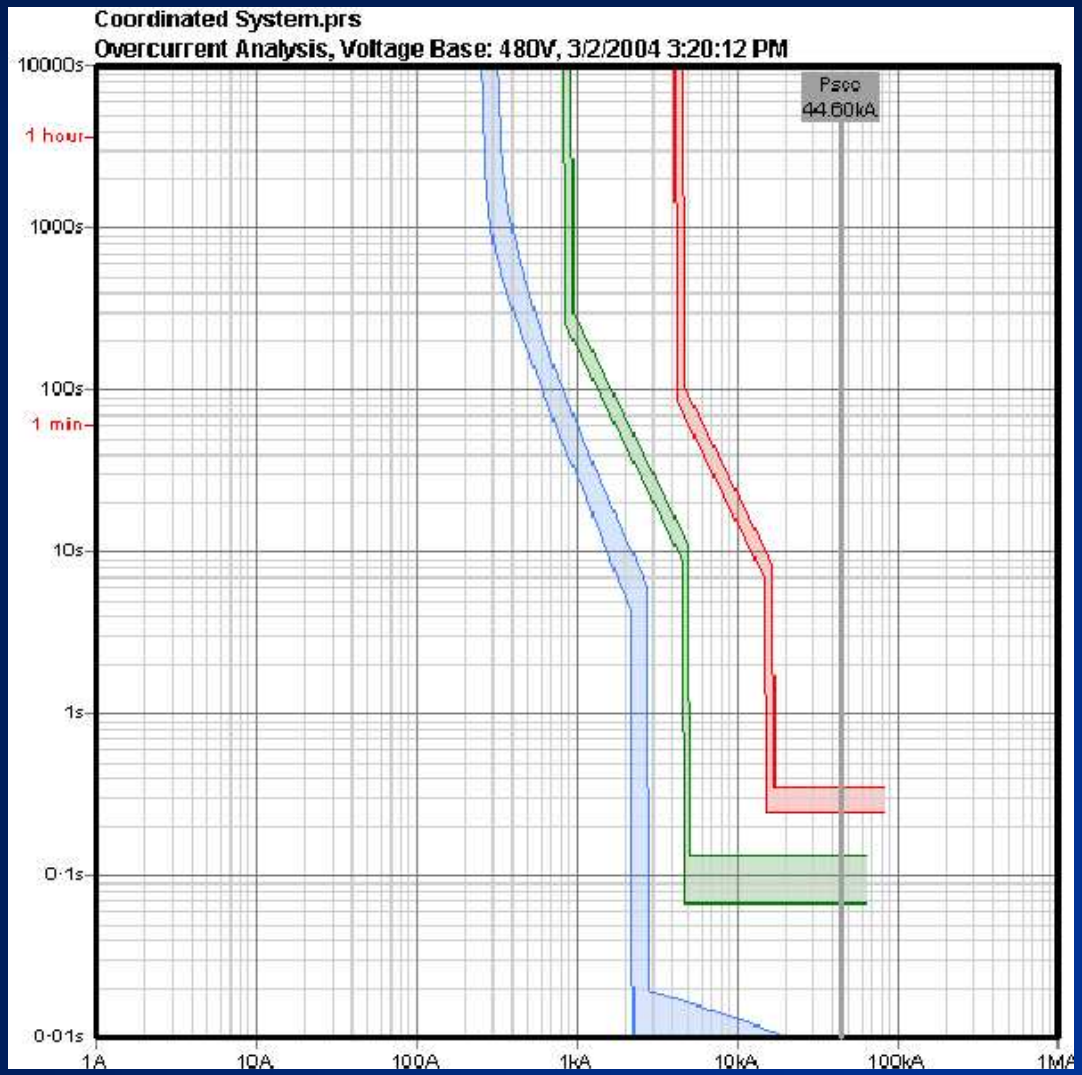
Time-Current Coordination System One-line Diagram



Time-Current Curves for a Non-Coordinated System



Time-Current Curves for a Coordinated System



Summary

- *All circuit breakers provide overcurrent protection*
- *Performance based on design standards and features*
- *Interrupting capacity, short-time current ratings, test power factor (X/R) determine ability to provide system protection, coordination, and selectivity*

Conclusions

- **MCCBs and ICCBs**
  - Excellent interrupting ratings but limited short-time current ratings
  - For improved selectivity choose a MCCB or an ICCB with a fixed internal instantaneous trip unit rather than an externally adjustable trip unit
- **LVPCBs**
  - Available without instantaneous trip elements and with high short-time current ratings
  - Some lower short-time current rating models are being introduced

High interrupting capacity does not necessarily mean high short time current rating