Low Voltage Circuit Breakers

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Low Voltage Circuit Breakers

What are all these things????

- Molded Case
- Insulated Case
- Thermal Magnetic
- UL489
- UL1066
- Metal Frame
- Solid State
- Power Breaker
- Fixed
- Standard
- ANSI Rated
- Fused
- 80% Rated
- 100% Rated
Low Voltage Circuit Breakers

- **Types of Circuit Breakers**
  - Molded Case Circuit Breakers
  - Low Voltage Power Circuit Breakers
Types of Circuit Breakers – What is a circuit breaker

- A circuit breaker’s function is to “break” a circuit if there’s an overload or a short circuit.
- A circuit breaker’s purpose is to protect a circuit, equipment and conductors from damage personnel in the event of an overload or short circuit.
- Circuit breakers can be used in control sequences in Power Control Systems.
- The American National Standards Institute (ANSI) defines a circuit breaker as “A mechanical switching device, capable of making, carrying and breaking currents under normal circuit conditions. Also capable of making and carrying for a specified time and breaking currents under specified abnormal circuit conditions, such as those of a short circuit.”
- The NEC defines a circuit breaker as “a device designed to open and close a circuit by non-automatic means, and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within it’s rating.”
Types of Circuit Breakers

- There are many different types of Circuit Breakers
- With lots of different names
- Molded Case
- Insulated Case
- Metal or Air Frame
- Universal
- And lots of others
- The name refers to how the breaker is made
- Names don’t describe the UL standard a circuit breaker meets, it’s interrupting rating or it’s quality
Low Voltage Circuit Breakers

- Types of Circuit Breakers
  - Molded Case Circuit Breakers
  - Low Voltage Power Circuit Breakers
Molded Case Circuit Breakers

What’s a molded case circuit breaker?

A molded case circuit breaker is defined as a circuit breaker that is assembled as an integral unit in a supportive and enclosed housing of insulating material – Basically a molded plastic case.

There are two types of molded case circuit breakers, thermal magnetic and solid state.

Molded Case breakers are listed to UL 489
Molded Case Circuit Breakers

- **Thermal Magnetic Circuit Breakers**: Circuit breakers that interrupt current when the current becomes too high by operating a trigger device (electromechanical trip unit) in the breaker. The contacts conducting the current are separated by preloaded springs. The circuit breaker registers the current either by the current's heating effect or by the magnetism it creates in passing through a small coil.
Thermal Magnetic Circuit Breakers

- **Thermal Trip** - used for overload protection
  - A bimetal strip made of two dissimilar metals bonded together. The two metals have different thermal expansion characteristics, so the bimetallic strip bends when heated.
  - When current flows through the strip, heat causes it to bend. The more current, the hotter it gets and the more it bends. When the strip bends a predetermined distance it makes contact with the trip bar and activates the trip mechanism opening the breaker
  - When the circuit breaker opens, the strip cools off and returns to its original position. The breaker can be manually reset once the overload condition has been corrected.
Thermal Magnetic Circuit Breakers

**Magnetic Trip** – used for short circuit protection

- Current flows through the breaker’s contacts creating opposing magnetic fields. When a short circuit occurs the forces increase significantly.

- The current that flows through the contacts also flows through a conductor that passes close to the circuit breaker’s trip mechanism. At fault current levels, the magnetic field surrounding the conductor provides sufficient force to unlatch the trip unit and trip the breaker.
Molded Case Circuit Breakers – 80% vs. 100% rated

■ What does an 80% breaker mean?

■ An 80% rated breaker as defined by the NEC requires the application load not to exceed 80% of the handle rating. Breakers are sized at 125% of continuous loads and non-continuous loads. Sometimes called a “standard breaker”

■ An 80% rated breaker can only be applied continuously (defined as 3 hours or more by the NEC) at 80% of its continuous current rating. 100% rated circuit breakers can be applied at up to 100% of their continuous rating continuously. Breakers rated at 80% can be applied at 100% of their rating if the loading will last for less than 3 hours.

■ There are different testing requirements in UL489 for 80% and 100% rated circuit breakers

■ Translation #1 – A 1000 Amp 80% rated breaker can carry 1000 amps for 3 hours per NEC. It can carry 800 amps forever.

■ Translation #2 – A 1000 Amp 100% rated breaker can carry 1000 amps forever.
Molded Case Circuit Breakers – 80% vs. 100% rated

■ It’s not just the NEC – From the UL white book

■ “Unless otherwise marked, circuit breakers should not be loaded to exceed 80% of their current rating, where in normal operation the load will continue for 3 hours or more”
Molded Case Circuit Breakers – 80% vs. 100% rated

Is this an 80% rated breaker or a 100% rated breaker?

You can’t tell by looking at the breaker. Some are identified on the label, some have to be checked by Part#.
Molded Case Circuit Breakers – 80% vs. 100% rated

■ FAQ: Will an 80% rated circuit breaker trip if 80% of its rating is exceeded??
■ Answer – No, the 80% rating is an NEC restriction designed to prevent over-heating and nuisance tripping of enclosed breakers and breakers in panelboards and switchboards

■ FAQ: Does a service entrance rated breaker have to be rated 100%
■ Answer – No, service entrance rated breakers can be rated 80%

■ FAQ: Is a 100% rated circuit breaker better than an 80% rated breakers
■ Answer – If applied properly and per code each will perform as required
Low Voltage Circuit Breakers

- Types of Circuit Breakers
- Molded Case Circuit Breakers
- Low Voltage Power Circuit Breakers
Are they all “Power Circuit Breakers”? It can be confusing. “Power Circuit Breaker” is an industry term, like “Utility Grade”. It implies something and is referred to in some standards (UL1066).

There are many standards they must meet.

Power Circuit Breakers are referred to by lots of different names:
- Metal Frame
- Insulated Case
- Air breakers
- ANSI Rated
- Dual Rated or Universal

And lots of different standards:
- UL1066
- UL489
- ANSI 37.50, 37.13, 37.16, 37.17
- NEMA SG-3
What’s the difference between an ANSI/Power/Metal frame breaker and an Insulated Case breaker?

■ An ANSI/Metal Frame breaker describes a circuit breaker that was traditionally built as an assembly of parts on a welded metal frame. It is tested to UL standard 1066 which requires compliance with ANSI standards C37.13, C37.16, C37.17 & C37.50. ANSI requires breakers to be drawout. Ex: SqD MTZ, Eaton Magnum DS, GE Wavepro, Siemens WL

■ An insulated case breaker is similar to a molded case breaker, built on a frame inside an “insulated” molded plastic case. They are tested to the same UL489 standard as molded case circuit breakers Ex: Eaton Magnum SB or SPB, GE Powerbreak, SqD SE, Siemens SB

■ At one time all breaker manufacturers had separate products lines for insulated case UL489 listed breakers and ANSI/metal frame UL1066 listed circuit breakers

■ The main difference is how they are tested. UL1066 tests for both interrupting rating and short time rating. UL 489 does not require the same short time test.

■ Over time the lines have blurred between the breaker types. Most manufacturer’s offer “dual rated” breakers. It’s not the name, it’s how the breaker is tested. Ex: SqD NW or MTZ, Eaton Magnum DS, Siemens WL, GE Entelligrad, ABB Emax2

■ Think UL1066 vs. UL 489
UL Standards - UL489 & UL1066

UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures

UL 1066 – Standard for Safety for Low-Voltage AC and DC Power Circuit Breaker used in Enclosures
UL Standards - UL489 & UL1066

- **UL 489**
  - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
  - April 25, 2002
  - (Title Page Reproduced: May 25, 2006)

- **UL 1066**
  - Standard for Low Voltage AC and DC Power Circuit Breakers Used in Emfuses
  - First Edition: January 1, 1985
  - Second Edition: March 1, 1992

### UL489
- No ANSI Standard requirements
- No short time testing
- Breakers rated at 80% or 100%
- 500 cycle endurance test
- Sealed case, fixed mount, no replaceable parts can prevent normal maintenance
- Used in **UL891 Switchboards** can not be used in **UL1558 Switchgear**

### UL1066
- Complies with ANSI Standards
- Requires Drawout Breakers
- Requires short time testing
- Breakers always rated at 100%
- 800 cycle endurance test
- Allows for maintenance of internal components - drawout
- Required in **UL1558 Switchgear** can be used in **UL891 Switchboards**
Low Voltage Power Circuit Breakers

- **What’s a power circuit breaker?**
- **Main Components**
  - Disconnects/Stabs
    - Main Disconnects – Connects breaker to main bus
    - Secondary Disconnects – Connects Control Circuits to the circuit Breaker
  - Arc Chutes – Interrupt and contain an arc
  - Main Contacts – Carries the load current
  - Operating Mechanism – Opens and Closes the circuit breaker – Spring mechanism
  - Overcurrent Trip Device – Solid State/Digital Trip unit
Low Voltage Power Circuit Breakers – Operating Mechanism

- Operating Mechanism – Opens and Closes the circuit breaker – Spring mechanism
- Springs provide the force to open and close the circuit breaker
- A “Charged” spring means the springs are compressed and are ready to open or close the breaker
- Spring charging accomplished via a manual charging handle on the front of the breaker or automatically via a charging motor
- The spring-charging motor automatically charges the spring mechanism for closing the circuit breaker and also recharges the spring mechanism when the circuit breaker is in the ON position. Allow for reclosing of the breaker after it’s been opened.

Manual Charging Handle  Operating Mechanism  Rotating Shaft

Internal Springs
Current Power Circuit Breaker Offerings

- Square D NW
- Square D MTZ
- Siemens WL & WLF
- Eaton Magnum DS
- ABB Emax2
- GE Entelliguard

*Power Circuit breakers are listed to UL 489 or UL1066*
What’s a Dual Rated or Universal Breaker?

A Dual Rated Breaker is a Breaker that meets both UL489 and UL 1066 Standards

A Universal Breaker meets both UL standards and IEC standards
And Just when you thought you had it figured out……

All of these manufacturers……

Square D NW
Square D MTZ
Siemens WL
Eaton Magnum DS
GE Entelligard

….Have UL489 and UL1066 versions of their breakers
Drawout Power Circuit Breaker – “Element”

Element – Current Carrying component
Drawout Power Circuit Breaker – “Cell”

- Cell
- Cradle
- Substructure
- Cassette
- Mounted in Switchgear or Enclosure
- Houses the Breaker Element
Power Circuit Breaker Features/Options

- All “Low Voltage Power Circuit breakers” are provided with Integral Solid State Trip Units that may have “Long, Short, Instantaneous and Ground Fault” trip settings.

Main purpose is to open the circuit breaker in an overload or short circuit event.
Solid State Trip Units

- Allows operator to program various settings via dials or screen
- Allows operator to adjust trip settings
- Can be provided with lots of display information, electrical parameters/metering, harmonics, trip data, event data
- Can be provided with communications options
- Provides Trip Indication
- QR Code with breaker information
- Bluetooth Connectivity
Solid State Trip Units - LSIG

- What do all these things mean?

- **Long Time** – Protection against overloads and short circuits. Causes the breaker to wait for inrush currents to subside without tripping. Long time delay is the length of time the breaker will hold an overload (running overcurrent) before tripping. **Sets the trip rating**

- **Short Time** – Protection against short circuits. Determines the amount of current the breaker will carry for a short time period, allowing downstream circuit protective devices to open and clear the fault without tripping the upstream breaker.

- **Instantaneous** – Protection against short circuits. Trips the circuit breaker with no intentional delay at any current typically between 2 and 40 times the breaker’s continuous ampere setting.

- **Ground Fault** – Protection against ground faults. Trips the breaker at a preset percentage of ground fault current.
Trip Unit Accessories – Arc Flash Protection

- Many circuit breakers can be provided with arc flash protection – Referred to as ERMS or ARMS
- Engaged when equipment requires maintenance within the Limited Approach Boundary but cannot be de-energized
- Does not eliminate arc fault incidents
- Decreases the hazard associated with an arc fault by decreasing the time the fault is allowed to exist
- Energy Reduction Maintenance Switch (ERMS) – Used for Arc Flash Protection.

When activated the trip curve settings are changed to a dedicated ERMS trip curve with adjustable L,S,I or G
- Some versions are based on a lower Instantaneous setting when activated
- Trip time can be reduced to as low as 30ms
- Can be activated from a dedicated, lockable switch or via Bluetooth with a smartphone App
- Complies with NFPA 70E
Solid State Trip Units – Zone Selective Interlocking

- Interconnects circuit breaker trip units.
- Short Time and Ground Fault functions can be interlocked.
- Downstream trip units tell upstream units a fault has occurred.
- Upstream trip unit doesn’t trip during the fault condition.
- Downstream unit immediately tells its breaker to trip.
- Requires proper coordination of breakers/trip units to work properly.
Power Circuit Breaker Features/Options

- Integral Solid State Trip Units – Trips the circuit breaker
- UL489 versions available in stationary or drawout configurations
- Interrupting capacity up to 200KAIC
- Electrically or Manually operated
- Shunt trip – Allows for remote electrical tripping of the breaker
- Bell alarm or Overcurrent Trip Switch(OTS) – Provides a contact to signal the breaker has been tripped
- 2 “a” & 2 “b” aux contacts – “a” is open when the breaker is open and “b” is closed when the breaker is open. All breakers in PCS systems are provided with 4a & 4b contacts
- Rating Plug – Sets the breaker trip rating
- Truck Operated Cell Switch (TOC) – Provides a contact to indicate the breaker is drawn out
- Undervoltage Release (UVR) – Trips the breaker upon a preset undervoltage setting
- Shutters
- Communications, metering, protective functions
- Hand Held & Full Function Test Kits
- Remote Racking Device
- Arc Flash Protection
Power Circuit Breaker – Electrically vs. Manually operated

Manually operated is exactly as it states. The circuit breaker is opened, closed and charged manually from pushbuttons and a charging handle on the front of the breaker.

- Breaker Open Pushbutton
- Breaker Close Pushbutton
- Charging Handle
Power Circuit Breaker – Electrically vs. Manually operated

- Electrically operated adds some accessories to operate the breaker “remotely”.

Electrically charges springs.
Receives close signal

Typically operates on
120VAC provided by via a CPT – Other AC or DC voltages available

Electrically opens Circuit Breaker

Typically operates on 24VDC from external source – Other AC or DC voltages available
Circuit Breaker Accessories

Open/Close Pushbutton Covers - A transparent cover blocks access to the push buttons used to open and close the circuit breaker. Cover is lockable.

Shutters automatically block access to the main disconnects when the circuit breaker is in the disconnected, test, or fully withdrawn position.
Remote Racking Device - Allows the operator to perform circuit breaker racking from a distance of up to 30 feet. Distance exceeds the arc flash boundary described in the arc flash safety guidelines in NFPA-70E.

1. Drive Unit
2. Control Unit
3. Control Cable – 30 feet
4. Power Cable
Circuit Breaker Accessories

**Full Function CB Test Kit** –
Verifies LSIG functionality, Trip Unit Operation, Mechanical Operation

**Hand Held CB Test Kit** –
Verifies Circuit Breaker Trip Unit Operation
Frame Size, Rating Plug, Trip Rating

- **Frame Size** – Maximum continuous current carrying capability a specific circuit breaker is capable of. Breaker can be damaged if the current exceeds the frame size.

- **Rating Plug** – Sets the maximum ampere trip level the breaker senses.

- **Trip rating** – The Ampere rating a breaker is set to trip at

- Ex: A 2000 Amp Frame circuit breaker can be provided with a 1600 Amp rating plug that is set to trip the breaker at 1000 Amps.
## Low Voltage Power Circuit Breakers - Ratings

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Type</th>
<th>Frame Sizes</th>
<th>AIC Ratings @ 480 Volts</th>
<th>Fusible</th>
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<tbody>
<tr>
<td>Square D</td>
<td>NW/MTZ – ANSI/UL 1066</td>
<td>800A – 6000A</td>
<td>Up to 200K</td>
<td>Not Available</td>
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<tr>
<td>Square D</td>
<td>NW/MTZ – UL489 Version</td>
<td>800A-6000A</td>
<td>Up to 150K</td>
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<tr>
<td>Siemens</td>
<td>WL – ANSI/UL 1066</td>
<td>800A – 5000A</td>
<td>Up to 150K - 200K w/fuse</td>
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<td>Siemens</td>
<td>WL – UL 489</td>
<td>800A – 5000A</td>
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<td>Eaton</td>
<td>Magnum DS – ANSI/UL1066</td>
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<td>GE</td>
<td>Entelliguard ANSI/UL1066</td>
<td>800A – 5000A</td>
<td>Up to 150K</td>
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<tr>
<td>GE</td>
<td>Entelliguard - UL489</td>
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<tr>
<td>GE</td>
<td>Wavepro – ANSI/UL1066</td>
<td>800A-5000A</td>
<td>Up to 85K w/fuse 200K</td>
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Low Voltage Circuit Breakers – Typical Applications

<table>
<thead>
<tr>
<th>Type</th>
<th>Paralleling Circuit Breaker</th>
<th>Distribution Circuit Breaker</th>
<th>Panelboard</th>
<th>Utility Circuit Breaker</th>
<th>UL891 Switchboard</th>
<th>UL1558 Switchgear</th>
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</thead>
<tbody>
<tr>
<td>Molded Case</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Insulated Case/UL 489</td>
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<tr>
<td>ANIS/UL 1066</td>
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<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
FAQ: Can all Power Circuit Breakers achieve 200KAIC@ 480V?

Answer – No, fused versions and some unfused versions can achieve 200KAIC.

FAQ: Can all Power Circuit Breakers be used in UL1558 switchgear?

Answer – No, Only UL 1066 listed breakers can be used in UL 1558 applications.

FAQ: Is Interrupting Rating the same as ATS Withstand Current Rating?

Answer – No, Interrupting rating defines the maximum short circuit current a circuit breaker can interrupt. Withstand Current Rating defines the ability of a transfer switch to withstand the thermal and electromagnetic effects of short circuit currents for a set period of time.