A Molded Case Circuit Breaker for the Digital Industrial Age
Increasingly, industrialized societies have become utterly dependent on a reliable supply of electricity. Unexpected service interruptions drive up the cost of goods and services to the point where the growth of an industry can be adversely affected. Limiting – or eliminating – power interruptions wherever and whenever they might occur is vitally important for major companies in mission-critical industries like oil and gas, information technology / data centers, mining and marine, factory automation, healthcare and others, because there is never a good time for unplanned disruption of power. Focusing on reducing unplanned downtime often means a thorough analysis of every essential point in a local electrical distribution system.

In the past, circuit breakers would passively react to anomalies in the electrical distribution system after they occurred, limiting their scope. But now, in today’s always-on world, actively preventing downtime caused by unforeseen circuit breaker failures has taken on increased importance. This white paper examines the technologies that have gone into a new generation of high-performance, full-featured molded case circuit breaker (MCCB) platform so that these circuit breakers address the needs of today’s demanding industrial and commercial electrical systems.

Global competition in practically every industrial sector is fierce and profit margins have thinned considerably as a result. Even a seemingly minor setback for an industrial company can seriously imperil its economic stability. As a consequence, these companies are ever vigilant, closely guarding the efficiency and productivity of their operations as well as the availability of the resources they rely upon to deliver products or services. Of course, some resources are more essential than others. A constant and dependable supply of electricity, for example, has become one of the bedrocks upon which growing companies are built. Any interruption in the electrical supply can be extremely costly.

Electrical disruptions of any kind can make or break a company in certain industry segments. Information technology data centers, for example, are particularly vulnerable. Recent research found that the average cost of an electrical outage at a data center would be approximately $690,200.¹ And, over the course of a year, data centers experience 13 such outages, costing more than $10 million USD to the bottom line.²

Data centers aren’t alone in this predicament. For an oil refinery, each arc flash incident in the plant’s electrical system can cost as much as $15 million USD.³ And power failures cause 1.2 refinery shutdowns a day in the U.S. alone.⁴ Plus, human life is at stake. Some 16 percent of oil field fatalities are caused by an electrical accident, explosion or burn.⁵

Electrical disruptions are also a concern for mining and marine companies. Unplanned downtime in mining operations, which is often caused by outages in a facility’s or a machine’s electrical distribution system, costs on average about $180,000 USD per incident.⁶ Ships are particularly at risk of non-productive time or electrical system downtime. On average, a drill ship loses about $12 million each year to non-productive time.⁷
Circuit breakers have always been vital to the reliability and safety of industrial electrical distribution systems. Until very recently though, their mechanical capabilities largely limited their role to reactive protection. When an incident occurred, the circuit breaker would protect the rest of the electrical distribution system and users from collateral damage. Now, improved high-performance technology supports proactive preventive maintenance operations that help reduce system downtime, improve productivity and thereby profitability while helping to enhance the safety of personnel. Data gathering and analytics are fundamental to achieving these goals.

Today’s advanced circuit breakers will not only store data about operating parameters at the time of manufacture, but also gather data about their performance over time and communicate this information when queried. A preventive maintenance system could then process this data, analyze it relative to the wear and tear on breakers, and recommend replacing those that are in jeopardy of failure. This helps to avoid downtime caused by an unexpected breaker failure and, at the same time, helps to enhance the protection of personnel.
GE’s new GuardEon family of MCCBs responds to the needs of this digital industrial age, where almost every industrial segment depends on a worldwide, always-on digital infrastructure. This MCCB platform is designed to stay a step ahead of the high-performance electrical demands of this global industrial environment while providing the kind of functionality and intelligence needed to ensure the operation of a digital infrastructure.

GuardEon, a global circuit breaker platform serving distribution needs from 15-1600 Amps, with currently availability ranging from 15A to 600A. And future frames will range upward to 1600A. The platform meets the requirements of all the major electrical certification bodies, including UL, IEC, cUL and CCC. Based on a simplified internal component design structure, these MCCBs are very reliable because they have fewer points of failure. In addition, many innovative features are shared among all three frames to reduce replacement parts inventories and enable easy field interchangeability, making technicians more productive by reducing the complexity of maintenance and repair procedures.

Moreover, the capabilities built into GuardEon are synergistic with the requirements of large electrical distribution systems as well as the Industrial Internet as a whole. For example, GuardEon interfaces seamlessly with GE’s low voltage EntelliGuard* air circuit breakers and both take advantage of GE’s ArcWatch* safety technology for ultimate protection from 15A up to 6,000A. And, in the wider world of the Industrial Internet, GuardEon supports a number of optional capabilities, including on-board circuit breaker diagnostics through industrial communications protocols like Modbus or through a direct connection via a micro USB cable.

**A Global Platform**

- UL, IEC, cUL, CCC certified
- Simple design for reliability, operation simplification
- Local late-point configuration centers to shorten supply chain worldwide
- Flexible configuration: Senses and adapts to connected hardware at installation, automatically implementing enhanced functions
- Common internal accessories reduce inventories

---

**The GuardEon Platform at a Glance**

<table>
<thead>
<tr>
<th>Amp Rating/ Poles</th>
<th>D FRAME</th>
<th>E FRAME</th>
<th>G FRAME</th>
<th>K FRAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,2,3,4</td>
<td>2,3,4**</td>
<td>2,3,4**</td>
<td>3,4</td>
<td></td>
</tr>
<tr>
<td>Thermal-Magnetic</td>
<td>Electronic PremEon S</td>
<td>Electronic PremEon S</td>
<td>Electronic PremEon S</td>
<td></td>
</tr>
<tr>
<td>Stored Energy</td>
<td>Toggle</td>
<td>Toggle</td>
<td>Toggle</td>
<td></td>
</tr>
</tbody>
</table>

* - UL / IEC Amp Range
** - 2-Pole is in a 3-Pole Footprint
Thinking Ahead – Diagnostics, Maintenance and Communications

In today’s digital industrial era, the ability to communicate and share data is an imperative. For GuardEon, essential data on the unit’s performance, physical condition and operating parameters can be monitored and analyzed to prevent, through preemptive maintenance procedures, unexpected circuit breaker failures and the resulting disruptions in electrical service. Instead of reacting after a circuit breaker has failed, this family of MCCBs provides the information needed to replace or repair a circuit breaker before it fails.

An example of the outstanding ‘smarts’ built into GuardEon and EntelliGuard circuit breakers is their mechanism timing feature, an innovation only available from GE.

When manufactured, each breaker captures the amount of time required to open its tripping mechanism and break the flow of current. Once installed, the circuit breaker stores this same timing information for the previous three times the circuit breaker opens. Technicians can use this data to determine any degradation in a circuit breaker’s mechanism opening speed. A significant deviation from the required performance could trigger replacing or repairing a circuit breaker before it fails. This data might also be interpreted by maintenance personnel that the circuit breaker could remain in place longer than expected, postponing or deferring the cost of maintenance or a replacement circuit breaker until it is absolutely needed.

Another feature which streamlines preventive maintenance is GuardEon’s ability to calculate and report the amount of metal remaining at the contact point in the current path through the trip unit. The contact point is opened when the circuit breaker detects a current overload condition, but if the metal, which is usually silver, has been eroded during operation, current may not pass through the contact point as efficiently as it should. This could eventually cause an unexpected failure of the circuit breaker. GuardEon is able to calculate the metal remaining at the contact point and, depending on how the local system has been deployed, an alarm could be sent to maintenance technicians informing them that the circuit breaker should be replaced.
Of course, knowing the condition of a circuit breaker’s mechanism timing and metal in the contact point is just the first step. Sharing this knowledge with operators or technicians is where the real value is. This can be accomplished either manually or electronically. An expansion module can be added to standard GuardEon MCCBs so that they can communicate over an industrial data communications network such as Modbus. If connectivity through an industrial network is not possible or required, performance and operating data can still be communicated to technicians through a direct connection via a micro USB cable and a personal or laptop computer.

In both cases, either over a network or through a direct connection, the data provided can be processed with GE’s Trip Unit Tool Kit, a powerful and complementary analytics software program downloadable from the GE website. The tool kit executes special software algorithms to examine and analyze a circuit breaker’s mechanism timing and contact wear data to enable predictive maintenance procedures. GuardEon’s ability to monitor and store performance and operating data, and then communicate it to the tool kit, eliminates the added cost of external test sets which typically are required by other less advanced circuit breakers. The tool kit can display data graphically as waveforms, event logs or even as real-time data so technicians and other users are able to immediately understand the implications of operating data. Circuit breaker parameters can be modified or troubleshooting routines can be run from the convenience of a PC. The Trip Unit Tool Kit gives users an intuitive interface through which GuardEon circuit breakers can be managed, monitored and tested. Learn more about GE’s Trip Unit Tool Kit free software.
Simplicity in Design

Extensive customer and field research led to several breakthroughs in simplicity and user-friendliness during the development of GuardEon. These features not only enhance the aesthetic appeal of a distribution panel or machine control panel, but, more importantly, they make the panel and the circuit breakers in it easier to install and operate, and simpler for technicians to understand what’s going on.

For example, the platform’s easier-to-read rotating faceplates can reduce human error and support correct operator action in less time. With rotating faceplates, it doesn’t matter whether the breaker is installed horizontally or vertically. Either way, the faceplate can be rotated so that it is always in the most readable position, right-side-up. Technicians and electricians can more easily read the faceplate than if, for example, a circuit breaker with a stationary vertical faceplate were installed horizontally, requiring the technician to turn his or her head awkwardly to read it. This is particularly useful in harsh environments like a swaying marine vessel or dust saturated mine site.

Another ease-of-use feature are the platform’s rotary handles. An extensive online innovation challenge was conducted over the entire user community with the intent of fine-tuning the ergonomics of the handles. Several of the features recommended by users were incorporated into the final design, resulting in rotary handles that are consistent across the entire platform. When tripped, each breaker’s rotary handle moves to the same position so that a technician can clearly and quickly see which breaker has been engaged. Human error is reduced and corrective action can be taken sooner.

Another feature that simplifies the installation and promotes the safety of GuardEon MCCBs is their integrated terminal cover. Other circuit breakers often include a separate plastic cover piece to protect the cable termination points. Unfortunately, installing these covers often requires extra steps for the technician. At times, the covers might be lost or simply not installed at all to save time. GuardEon’s terminal covers are already in place, attached by a hinge to the body of the circuit breaker. The installer simply snaps the cover closed after the cables have been terminated.
Configurability, Flexibility

One of the main advantages of the advanced technologies designed into the GuardEon platform is the configurability of each individual circuit breaker. In fact, the final configuration of an MCCB does not take place when the circuit breaker is manufactured. Breakers are shipped from the factory to late-point configuration centers located strategically across the globe. In these centers, the MCCBs are quickly configured to meet the specific requirements of purchase orders. Instead of waiting for a purchase order to manufacture circuit breakers with the required capabilities, the circuit breakers inventoried in one of these centers can be quickly configured to local requirements and delivered, streamlining the supply chain considerably.

Even after a GuardEon circuit breaker is installed at a customer site, certain features can be re-configured or adjusted. For example, if the requirements of an application have changed since the breaker was ordered, the circuit breaker can be adapted on site to meet the new requirements. Moreover, technicians in the field can add new capabilities through one of the platform’s expansion modules. For example, previously, an upgrade in a plant or a certain machine might have required replacing all the installed circuit breakers, but GuardEon MCCBs new plug-and-play features like data communications and zone selectivity can be added and total replacement costs can be avoided.

The needs of a user or an application will determine how and which of the platform’s diagnostic, maintenance and communications capabilities are implemented in each individual case. Another example of the re-configurability of these MCCBs is their adjustable load ratings. Previously, few options were available short of replacing a circuit breaker in the field if its load rating had to be changed. Eventually, rating plugs somewhat alleviated this problem. A circuit breaker’s rating plug could be changed to alter its rating without replacing the entire MCCB. Later, electronic trip units supplanted rating plugs so that a circuit breaker’s rating could be altered by simply turning a knob. Now, GuardEon is the first GE circuit breaker platform to eliminate rating plugs entirely across the entire line and substitute adjustable rating dials. In other words, GuardEon has the flexibility and configurability to adapt to changing load demands after it’s installed. This also reduces the inventory of spare circuit breakers and parts, like rating plugs, that a maintenance technician must manage.

Besides adjustable load ratings, several other aspects of a GuardEon circuit breaker can be changed by a technician in the field to substantially alter its capabilities. These features include the trip unit, and ground fault capability. GuardEon supports several field interchangeable trip units, including a thermal magnetic unit, as well as GE’s electronic units, the PremEon S and PremEon G.

In addition to these field interchangeable elements, the inherent capabilities of a GuardEon MCCB with a PremEon G trip unit can be supplemented by installing expansion modules. For example, data communications over an industrial network like Modbus could be added to all or a group of circuit breakers so that certain machines or a section of a factory might be included in a supervisory control and data acquisition (SCADA) system or a building automation system.

With another expansion module known as protective relays, users can set up alarms or alerts that would be communicated to a computer to inform an attendant when certain conditions occur. In many cases, an alert might be set up to protect valuable assets on the electrical distribution system, such as an expensive machine on a factory production line. For example, an under-voltage condition might cause an expensive machine to overheat. To avoid this, GuardEon could notify a technician monitoring the factory floor so that prompt corrective action can be taken.

Several safety-related expansion modules can be added to enhance the protection of personnel. One such feature, reduced energy let-through or RELT maintenance switch, is a capability of GuardEon MCCBs with the PremEon G trip unit. RELT protects electricians and technicians when they are working around high-power equipment or facilities. When engaged, RELT reduces the current allowed through the circuit breaker to the lowest possible level. This reduces the risk and size of a hazardous arc flash incident - should one occur - while workers are in the area. RELT can be engaged manually or automatically through motion sensors.

A second safety feature is instantaneous zone selective interlocking (I-ZSI). This is a communications capability which enables hierarchical coordination among GuardEon and EntelliGuard circuit breakers. I-ZSI helps circuit breakers work together to determine how to compartmentalize a service
interruption and still protect the wider distribution system. For example, an upstream (closer to the source) K Frame GuardEon circuit breaker might detect an overcurrent condition at the same time as a downstream (closer to the load) GuardEon E Frame circuit breaker. The upstream circuit breaker would cede responsibility to the breaker closer to the condition to reduce the portion of the distribution system affected and to pinpoint where the cause of the problem is.

I-ZSI is one of a set of capabilities in GE’s ArcWatch® safety technology, which is found in a number of circuit breaker families’ trip units and switchgear. ArcWatch strikes a balance between reducing the possibility of an arc flash and maintaining dependable electrical service. ArcWatch virtually eliminates the compromises that were once a necessity.

Without ArcWatch, maximum protection from an arc flash meant making the circuit breakers sensitive to every anomaly in the electrical system, but this could compromise service reliability by overreacting to minor fluctuations. The opposite could also occur. Less sensitive settings in the circuit breakers to avoid needless interruptions might compromise arc flash protection. With ArcWatch technology, the electrical system can be sensitive and react quickly without needlessly jeopardizing the dependability or availability of large portions of the distribution network. Through its intelligent decision making and instantaneous coordination, ArcWatch selectively reduces the portion of the system affected by a service outage.

ArcWatch Technology Throughout GE Product Families

• EntelliGuard air circuit breakers and trip units
• Spectra microEntelliGuard circuit breakers
• Record Plus circuit breakers
• Evolution Series 9000 MCC
• Entellisys & AKD-20 Switchgear
• GuardEon molded case circuit breakers and trip units
User-Driven Development

Although not unusual for GE, the exhaustive research and user outreach process that drove the development of the GuardEon platform’s extensive capabilities are unprecedented in the power industry. Early in the product development cycle, numerous focus groups gathered useful intelligence on the features and functionality users preferred or disliked. These focus groups were staged throughout the major regions of the world to ensure that a truly global platform would be developed. To gather even more input on one feature in particular, an online crowdsourcing contest solicited innovative ideas from industrial users. The best of these concepts eventually formed the basis for the MCCBs’ rotary handle design.

Much of GuardEon’s design and development took place in GE’s New Product Introduction (NPI) lab, a multi-disciplinary think tank. Here, experts in design, supply chain, quality assurance, manufacturing, finance and other pertinent fields were all focused on one goal, developing and bringing to market an MCCB platform that would meet today’s needs of the industrial Internet with innovative solutions and breakthrough new capabilities for the future.

As the design phase progressed, the development team followed GE’s FastWorks method to validate the features and functionalities of the MCCBs with potential users. Periodically, portions of the platform’s design would be sent to groups of potential users who would test the product and provide feedback, both positive and negative.

At a critical junction in the development process, the manufacturing engineers on the NPI team brought in additional expertise by involving GE’s Advanced Manufacturing Lab (AML). The objective of the AML is to fine-tune the design-for-manufacturability of electrical distribution products. GE has made a considerable investment in the lab, equipping it with the tools and technologies, such as robotics, programmable logic controllers and other sophisticated machinery, that are essential to innovative and highly productive manufacturing lines.

The lab’s manufacturing engineers collaborated with GuardEon’s NPI design team to ensure the MCCBs could be manufactured and assembled on the most advanced factory automation systems. The AML’s first task was to analyze how the product design might be enhanced relative to the requirements of factory automation machinery. Once these aspects of the design were fully implemented, the AML set about modeling and developing the actual systems that would be deployed in the production lines in the new factory built specifically for GuardEon.
Conclusions

The digital evolution of the last decade has wrought radical changes throughout societies, national economies and industrial enterprises. Now, industrial companies are challenged to become even more productive than they are already. And this at a time when enterprises are more reliant than ever before on electrical power to operate their facilities, systems and machines. The GuardEon MCCB platform bridges the past with the future. GuardEon takes advantage of the best tried-and-true circuit breaker capabilities found throughout GE’s products while tapping into new technologies, functionalities and better ways of doing things in the digital industrial era.

Authors

Tim Ford, Global Product Manager, Molded Case Circuit Breakers (MCCB) GE’s Industrial Solutions business
Derek Leitzke, Product Manager, MCCBs for New Product Introduction (NPI) GE’s Industrial Solutions business

Sources

5. Source: According to a study of oil and gas producers in 102 countries: http://ogp.org.uk/pubs/455.pdf

GE
4200 Wildwood Parkway
Atlanta, GA. 30339 USA
www.geindustrial.com