Enabling a Solid State Circuit Breaker

USING SOLID-STATE CIRCUIT BREAKERS TO REVOLUTIONIZE POWER DISTRIBUTION

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Atom Power, Inc.
Requires a focus on:

- Safety
- Reliability
- Cost
- Useability
Traditional Circuit Breakers

MV Drawout

Insulated Case

Molded Case
*(vast majority)*
Traditional Circuit Breakers

- Mechanical in nature
- Interrupt rating related to arc chamber capability
If you could create an ideal circuit breaker what would it look like?

- Core is a SiC based power module
- Variety of sensing techniques
- Intelligent processing
- Application for user interaction and system visibility
Disruption of Traditional Circuit Breaker Market

Power Semiconductor

Sensing

Brains

Control
Today's Circuit Breaker

- 70A RMS, steady state
- Short Circuit state
- Overload state
- Short Circuit envelope
- One (1) 60Hz cycle
- Faster breakers trip point

100A circuit breaker example
Solid State Circuit Breaker

Extremely Fast Detection (usec)

100,000 Amp Interrupt Capacity

Arc Flash Energy reduced by 3000x

- Creating a Safer Building -
Product Safety - UL 489

UL 489, Molded Case Circuit Breakers

- Established product safety standard developed for traditional circuit breakers

- Very robust and challenging standard, covers both product safety and performance

- Test developed to address mechanical and thermal breakers

- Standard did not anticipate having a solid state device used to carry/detect current and limit let through current during fault conditions

We are breaking new ground!
<table>
<thead>
<tr>
<th>Test</th>
<th>Description</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>X Sequence</td>
<td>1. 200% Irated, 25C, trip in &lt; 6 min</td>
<td>X, Y and Z sequence are rigorous test suites</td>
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<tr>
<td></td>
<td>2. 135% Irated, 25C, trip in &lt; 2 hrs</td>
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<td></td>
<td>3. Overload, 600% Irated, 50 cycles, 0.45pf</td>
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<td>4. 100% Irated, 40C</td>
<td></td>
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<tr>
<td></td>
<td>5. 100% Irated, 25C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Dielectric</td>
<td></td>
</tr>
<tr>
<td>Z Sequence</td>
<td>1. 200% Irated, 25C, trip in &lt; 6 min</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Interrupting</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. 200% Irated, 25C, trip in &lt; 6 min</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Dielectric</td>
<td></td>
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<tr>
<td>EMC</td>
<td>IEC 61000-4-2(ESD), IEC 61000-4-3(radiated immunity), IEC 61000-4-4(transient), IEC 61000-4-5(surge), IEC 61000-4-6(conducted immunity), CISPR 22 (radiated emissions)</td>
<td>Robust EMC test suite</td>
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</tbody>
</table>
Product Safety - UL 489

Considerations that are unique to a SSCB

- Forced air cooling not supported

- Surge and fast transient testing configuration does not represent end unit installation

- Rigidness in interpretation of the standard

UL 489 is critical but not sufficient to assure reliability of product
Reliability Through Intelligence

- Tight coupling between hardware and firmware
- Settable trip points
- Voltage, current and frequency measurement capability
- Built in redundancy and fault diagnostics

Current Sense

Voltage Sense

Temp Sense

di/dt

rms

Intelligence
Reliability Through Intelligence

- Safety approved firmware self test libraries
- Self test runs in conjunction with real time control code
- Power on self test
- Memory built in self test
● Disproportionate cost allocated to SiC Modules

● Expect SiC modules to have accelerated cost reduction path compared to electrical and mechanical components.

● Focus on critical arc flash reduction applications

● Consider applications where circuit breaker combines functionality not possible with traditional circuit breaker
Usability

- Visibility of System Status
- User Control and Freedom
- Match Between System and Real World
- Recognition Rather than Recall

Sample of Jakob Nielsen’s general principles for interaction design
Usability

- Match look of breaker panel
- See status of individual breakers within the panel
- Panel and breaker naming
- Ability to dive into each breaker status and settings
Usability

- Match look of actual breaker
- TCC curve that is familiar and easy to understand
- Adjustable TCC curve
- Ability to coordinate protections within a building
Usability

- Event log maintained
- Historical record of state changes, faults, and breaker setting changes
- Comprehensive suite of fault reporting
Our Space (today)

Circuit Breakers

3-phase & 2-pole
480VAC
208VAC

for commercial & industrial buildings
Atom Power Products

Atom Panel™
(Aggregator)

Atom Switch™
(Circuit Breaker)

Atom OS™
(Interface)
A Summary of things the Atom Switch can do...

- Arc flash mitigation (low impedance faults)
- Destructive short circuit hazard mitigation
- Ultra fast circuit protection - μs round trip fault detection and circuit opening in an instantaneous trip scenario.
- 100,000-amp interrupting capacity
- Remote operation - each Atom Switch is remotely controllable through Atom OS™ or through your own inputs into the Atom Panel (sensors, contacts)
- Dynamic time-current curve adjustment of each Atom Switch from 15-100 amps
- Surge Protection
- Thermal memory
- Remote firmware update capability
- Easily networked with one (1) IP address for the whole thing

- Motor soft-starting capability with ramp-up and ramp-down time adjustable from 1-30 seconds
- Integrated metering:
  - Volts
  - Amps
  - Power
  - Temperature
- Integrated relay functions:
  - Under/over voltage protection
  - Under/over current protection
  - Under/over frequency protection
  - Phase loss protection
- Power flow scheduling through Atom OS
- Autonomous - each Atom Switch has its own firmware, enabling autonomous, fail-safe operation
- Integral lockout/tagout air gap mechanism for maintenance
Atom Switch™
Solid-state Circuit Breaker
Intelligent & Self-aware
Dynamic
Safer than anything in the world
Thank You

Mike Harris
Atom Power, Inc.
Help make the world a better place

Designed & Built in Charlotte, North Carolina
www.atompower.com