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# Enabling a Solid State Circuit Breaker

USING SOLID-STATE CIRCUIT BREAKERS TO  
REVOLUTIONIZE POWER DISTRIBUTION

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Atom Power, Inc.

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# Enabling an Intelligent Solid State Circuit Breaker

Requires a focus on;

- Safety
- Reliability
- Cost
- Useability

# Traditional Circuit Breakers

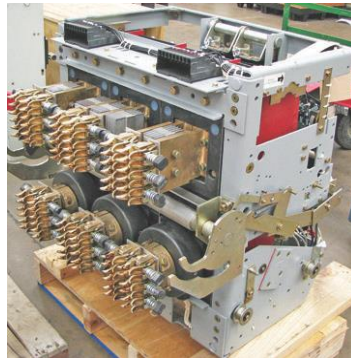


MV Drawout

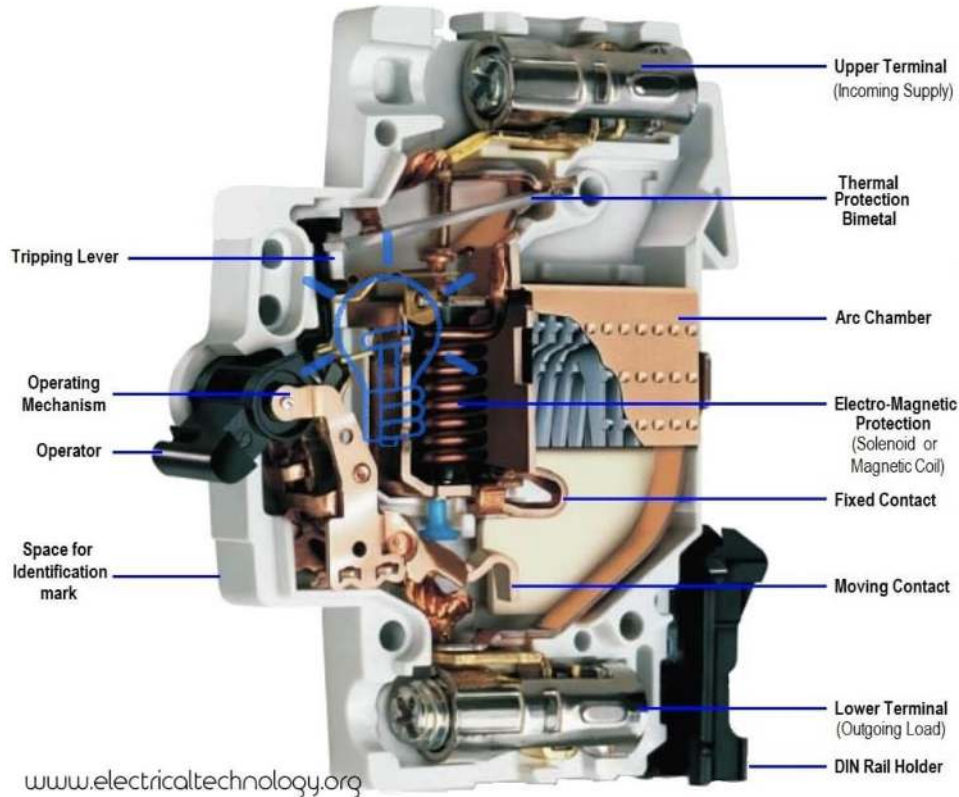


Insulated Case

Molded Case  
*(vast majority)*



# Traditional Circuit Breakers



- Mechanical in nature
- Interrupt rating related to arc chamber capability

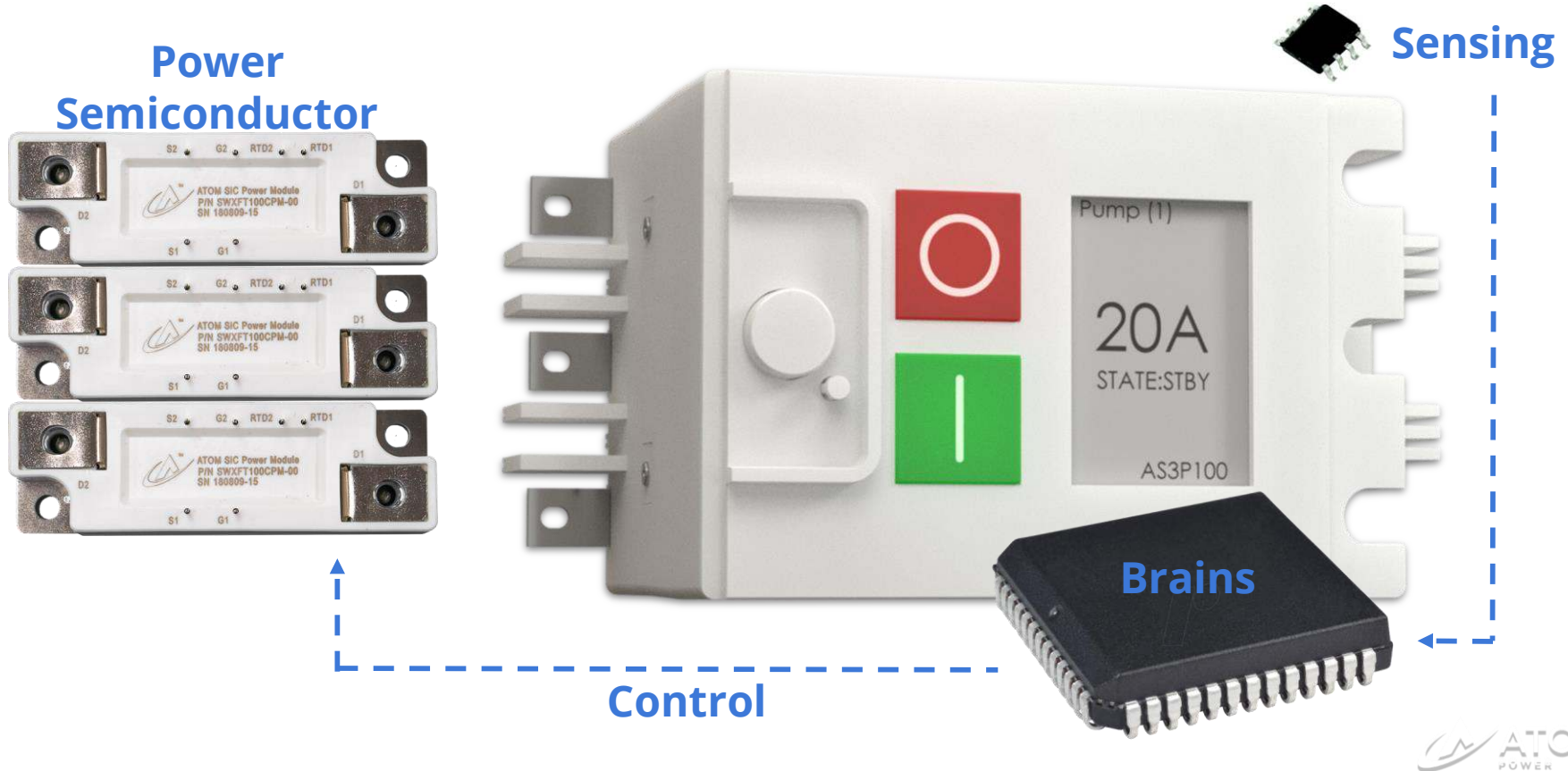
# WBG Enabled - Digital Device



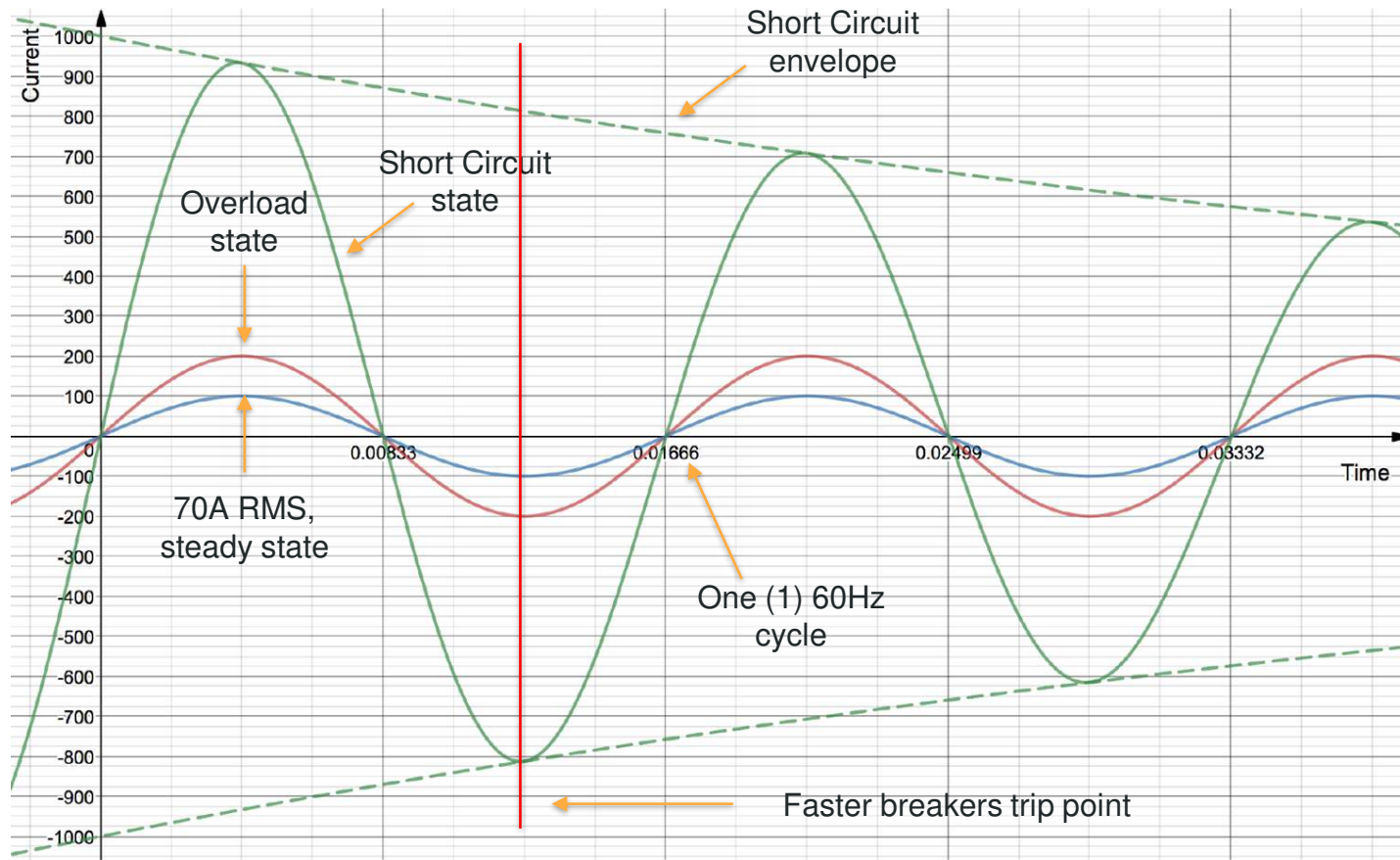
If you could create an ideal circuit breaker what would it look like?

- 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

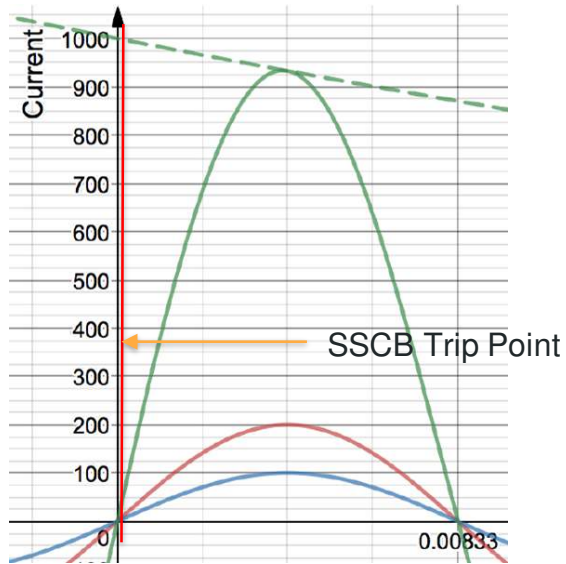


# Today's Circuit Breaker



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 !**

# Product Safety - UL 489

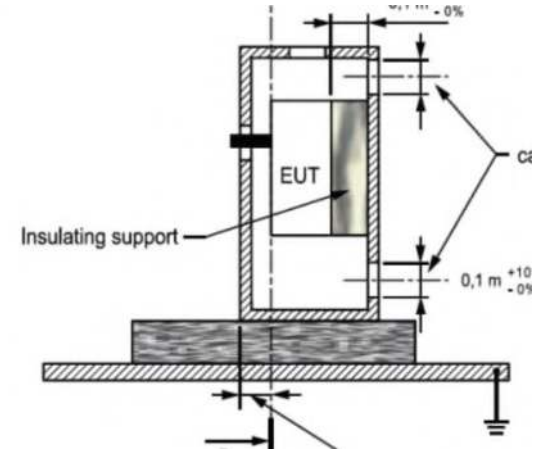
Test	Description	Comments
X Sequence	<ol style="list-style-type: none"><li>1. 200% Irated, 25C, trip in &lt; 6 min</li><li>2. 135% Irated, 25C, trip in &lt; 2 hrs</li><li>3. Overload, 600% Irated, 50 cycles, 0.45pf</li><li>4. 100% Irated, 40C</li><li>5. 100% Irated, 25C</li><li>6. Dielectric</li></ol>	X,Y and Z sequence are rigorous test suites
Z Sequence	<ol style="list-style-type: none"><li>1. 200% Irated, 25C, trip in &lt; 6 min</li><li>2. Interrupting</li><li>3. 200% Irated, 25C, trip in &lt; 6 min</li><li>4. Dielectric</li></ol>	
EMC	IEC 6100-4-2(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)	Robust EMC test suite

# Product Safety - UL 489

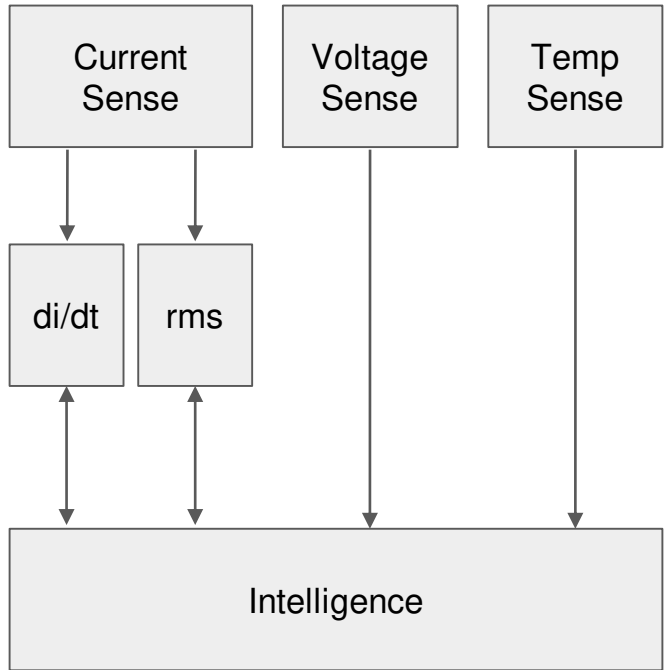
## Considerations that are unique to a SSCB

- 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



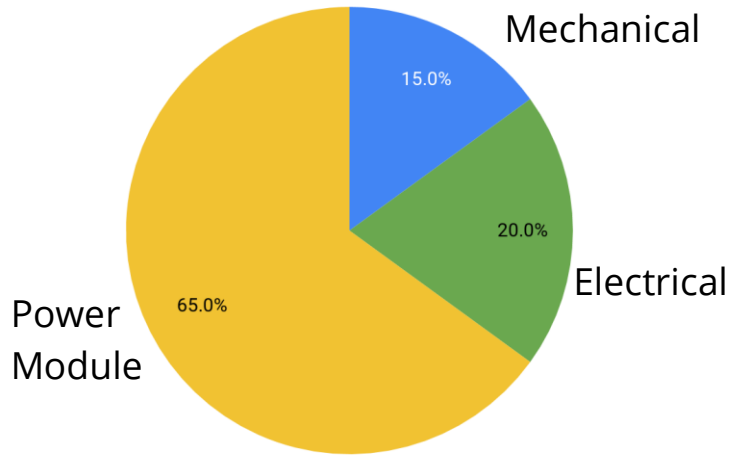
- Tight coupling between hardware and firmware
- Settable trip points
- Voltage, current and frequency measurement capability
- Built in redundancy and fault diagnostics

# Reliability Through Intelligence



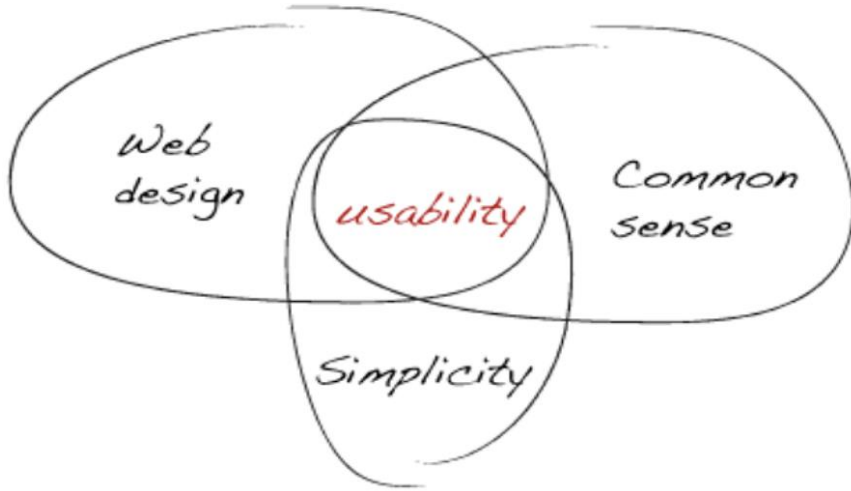
- Safety approved firmware self test libraries
- Self test runs in conjunction with real time control code
- Power on self test
- Memory built in self test

# Product Cost



- 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

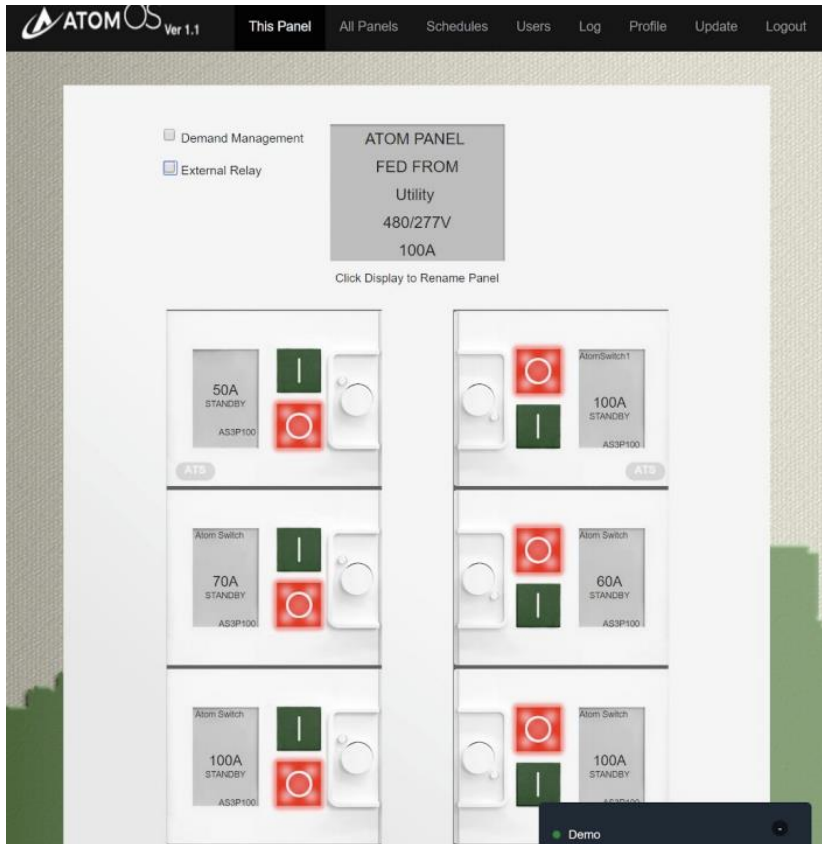


- Visibility of System Status
- User Control and Freedom
- Match Between System and Real World
- Recognition Rather than Recall

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

ATOM OS Web 1.1

This Panel All Panels Schedules Users Log Profile Update Logout

EVENT LOG Event Error

S.No	Parameter	Operation	Change	Switch Name	Date	Time	User
1	STANDBY	MANUAL	State	AtomSwitch	2018-08-02	08:14	-
2	OPEN	ATOMOS	State	AtomSwitch	2018-08-02	08:14	-
3	OPEN	ATOMOS	State	AtomSwitch	2018-08-02	08:14	ryan
4	STANDBY	MANUAL	State	AtomSwitch	2018-08-02	08:14	-
5	CLOSE	ATOMOS	State	AtomSwitch	2018-08-02	08:14	ryan
6	UNDER-VOLTAGE	INTERNAL RELAY	State	AtomSwitch1	2018-08-02	08:18	-
7	STANDBY	MANUAL	State	AtomSwitch1	2018-08-02	08:18	-
8	UNDER-CURRENT	INTERNAL RELAY	State	AtomSwitch1	2018-08-02	08:18	-
9	VOLTAGE-IMBALANCE	INTERNAL RELAY	State	AtomSwitch1	2018-08-02	08:20	-
10	CURRENT-IMBALANCE	INTERNAL RELAY	State	AtomSwitch1	2018-08-02	08:20	-
11	STANDBY	MANUAL	State	AtomSwitch1	2018-08-02	08:20	-
12	UNDER-CURRENT	INTERNAL RELAY	State	Switch	2018-08-02	08:38	-
13	STANDBY	MANUAL	State	Switch	2018-08-02	08:38	-
14	CLOSE	MANUAL	State	Atom Switch	2018-08-02	09:10	-
15	STANDBY	MANUAL	State	AtomSwitch1	2018-08-02	09:10	-
16	STANDBY	MANUAL	State	Atom Switch	2018-08-02	09:10	-
17	STANDBY	MANUAL	State	Atom Switch	2018-08-02	09:10	-
18	STANDBY	MANUAL	State	Atom Switch	2018-08-02	09:10	-
19	STANDBY	MANUAL	State	Atom Switch	2018-08-02	09:10	-
20	STANDBY	MANUAL	State	Atom Switch	2018-08-02	09:10	-

Page 1 of 5

1 2 3 4 5

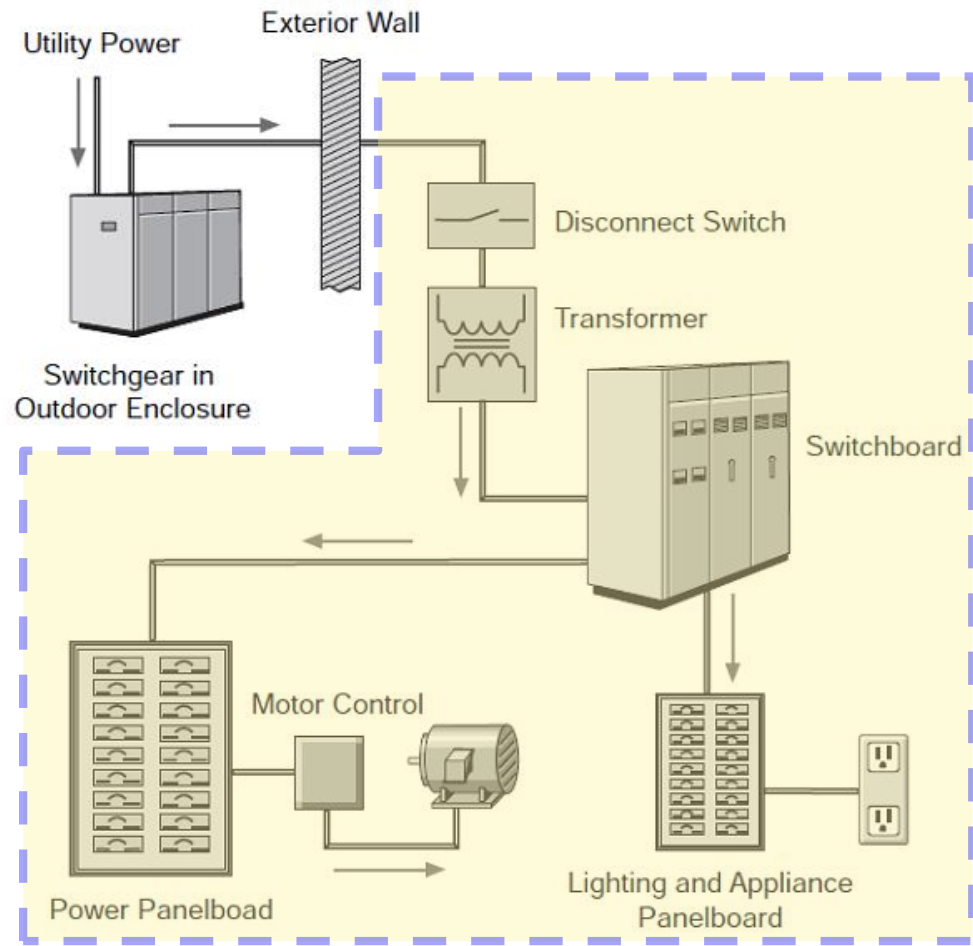
- Event log maintained
- Historical record of state changes, faults, and breaker setting changes
- Comprehensive suite of fault reporting

# Our Space (today)

## Circuit Breakers

3-phase & 2-pole  
480VAC  
208VAC

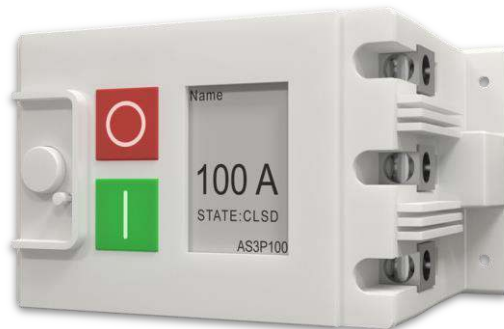
for commercial &  
industrial  
buildings



# 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 -  $\mu$ s 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

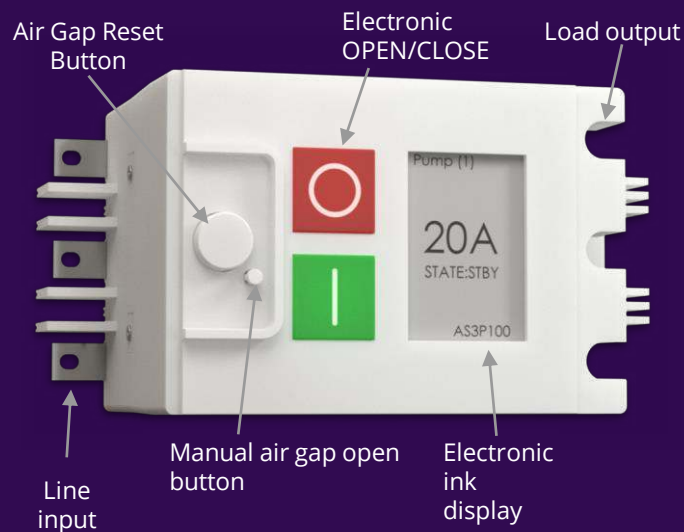
# Atom Switch™

Solid-state Circuit Breaker

Intelligent & Self-aware

Dynamic

Safer than anything in the world



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# Thank You

Mike Harris  
Atom Power, Inc.



Help make the  
world a better  
place



Designed & Built in Charlotte, North  
Carolina  
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