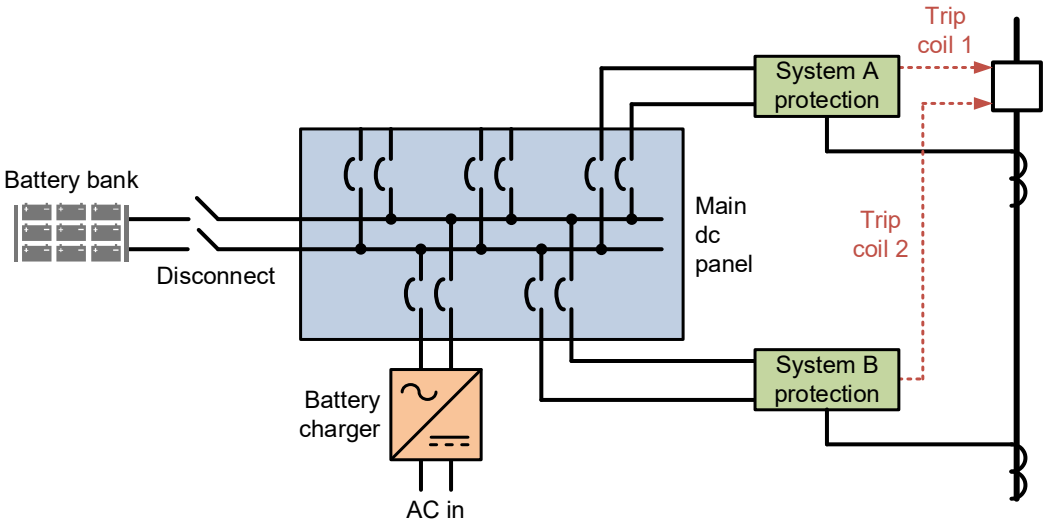
Combining Battery and AC Sources for More Reliable Control Power

Edmund O. Schweitzer, III, David E. Whitehead, Michael Thompson, Krishnanjan Gubba Ravikumar, Austin Wade, Bruce Hall, and Sean Robertson
Schweitzer Engineering Laboratories, Inc.

Overview

- Reliable control power
- Combining control power sources
- Energy storage
- Diversity strategies
- Applications that benefit from reliable control power

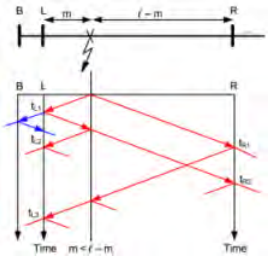
DC system



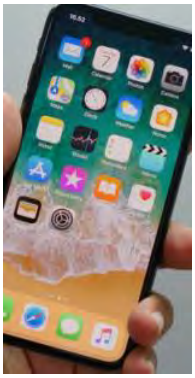
1950s battery bank

My grandfather's battery bank

The year is 2021…

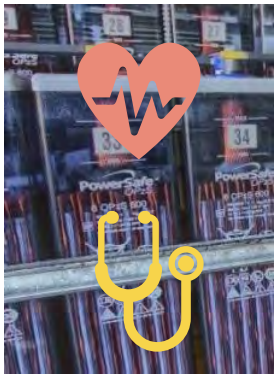


Traveling-wave relays



Pocket computers

Landing rockets



Today's battery banks

How does control power fail?

Battery failure

DC control system faults

Battery charger failure

Human error

Why use station batteries?

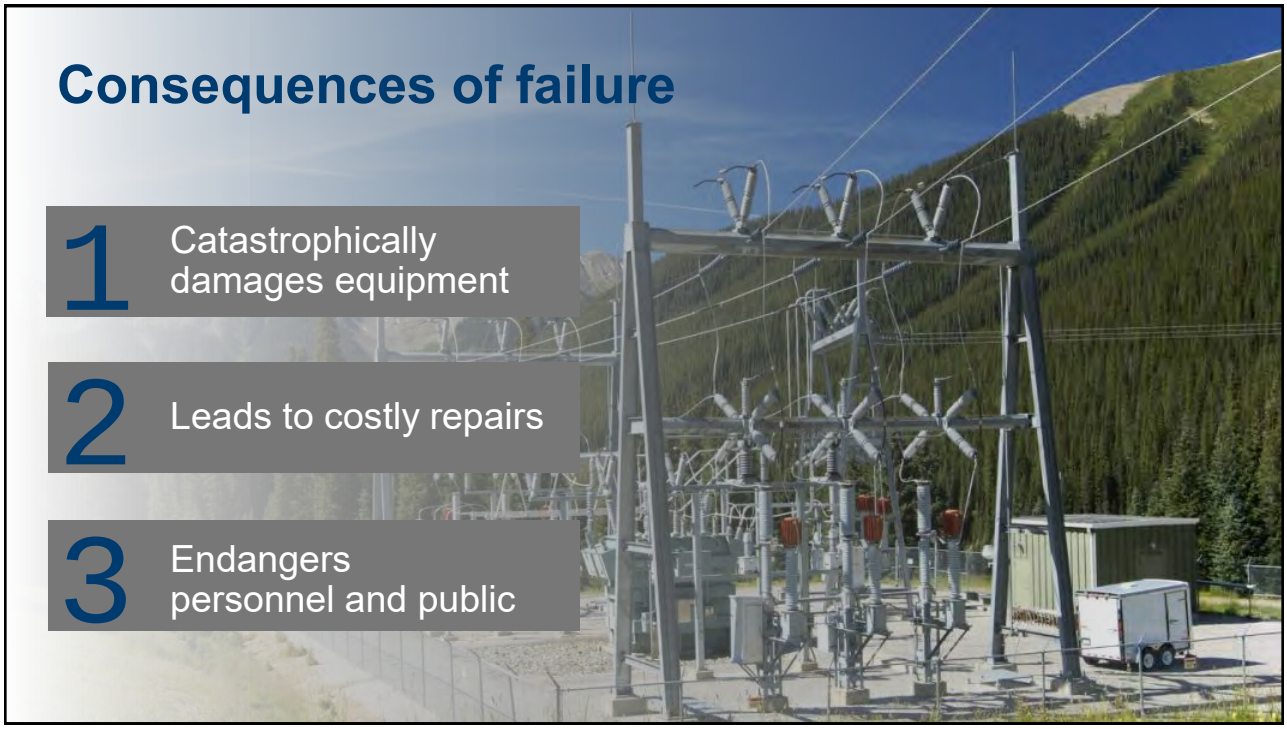
- Provide isolation between protection and the power system it protects
  - Fault depresses voltage
- Provide reliable power until repairs can be made to station service or charger
  - Energy storage capacity
- Provide momentary high current for tripping
  - Maximum discharge rate

Consequences of interruptions

Loss of availability

IED	Startup time (s)
Manufacturer A relay	<5
Manufacturer B relay	30
Automation controller	60
Station computer	500 – 1,000

Consequences of failure

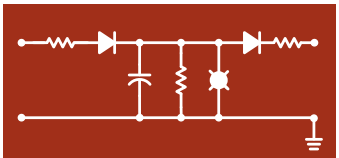


1. Catastrophically damages equipment
2. Leads to costly repairs
3. Endangers personnel and public

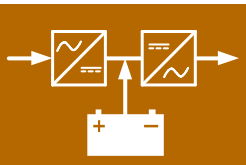
Today's solutions

Dual station battery systems

Monitoring



Capacitive trip units



Uninterruptible power supplies

Computer

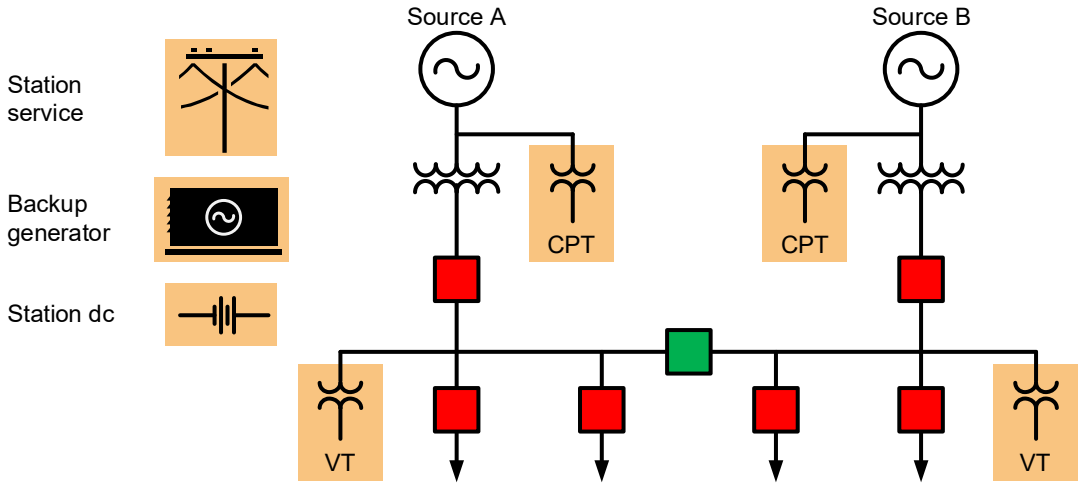
PS1 | PS2

Dual power supplies

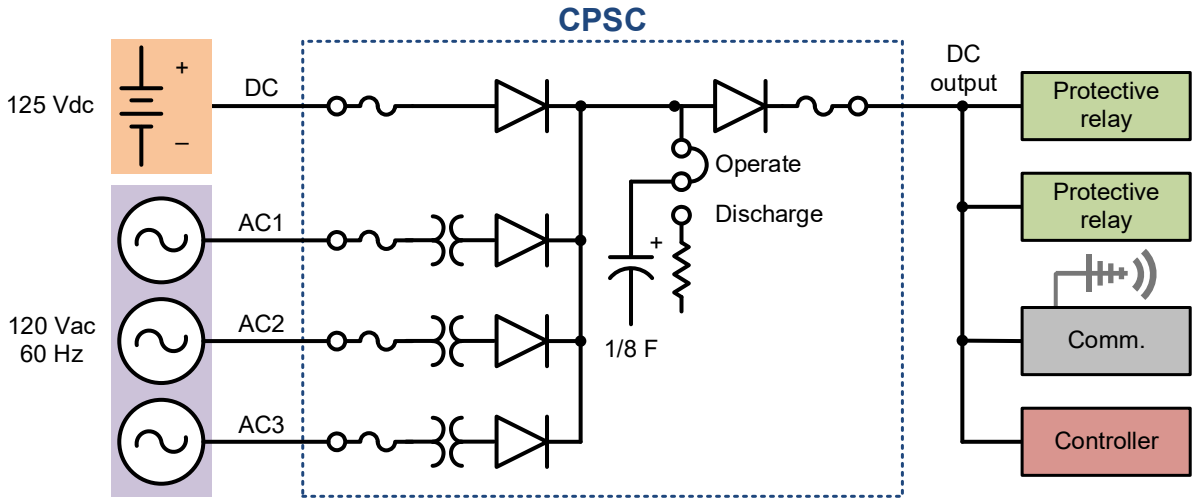

Water, water, everywhere,
Nor any drop to drink


Power, power, everywhere,
Nor any source avails

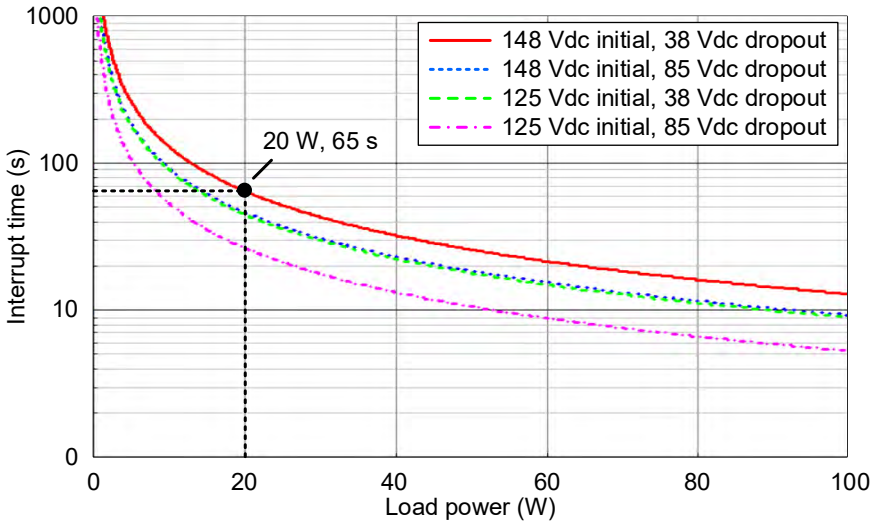
Can we use all sources of control power?



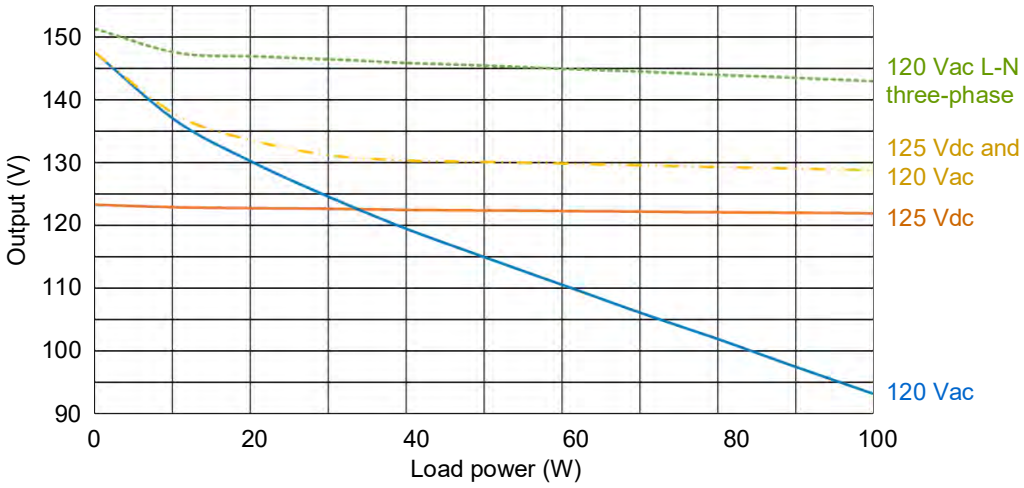
Combine dc with isolated ac and store energy in large capacitor



Ride-through times for total loss of source

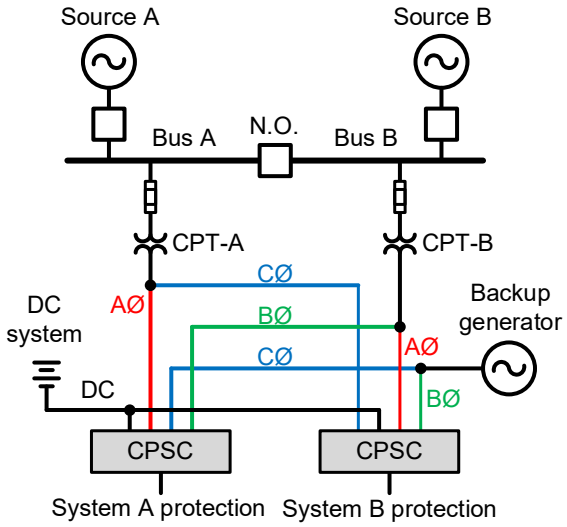


Output voltage depends on input and load



Designing reliability using diversity

- Connects to different source locations
- Uses different phases
- Systems A and B connect to different sources

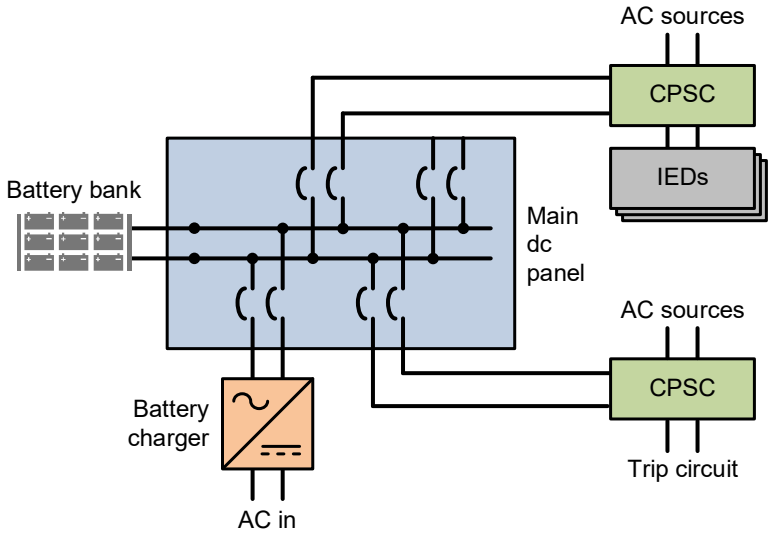


Applications benefitting from reliable control power

- Stations without dual batteries
- Battery maintenance
- Stations with no battery
- Safety scheme
- Electromechanical relay replacement

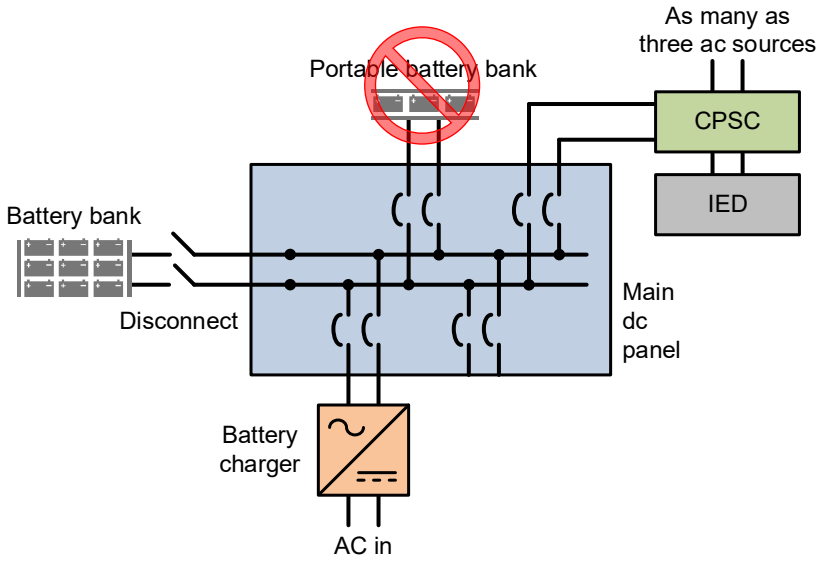
Typical station without dc redundancy

- CPSC is in branch circuits
- CPSC provides alternative energy source to trip breakers



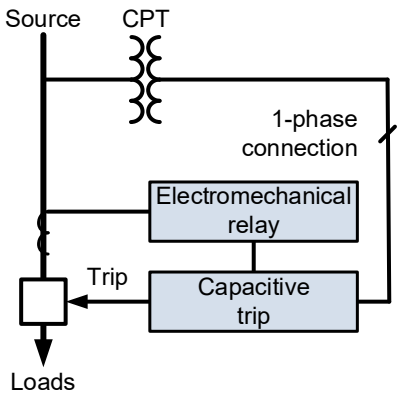
Maintenance and human performance

- Eliminates need for portable battery banks
- Provides energy to trip breakers in an emergency
- Reduces human errors



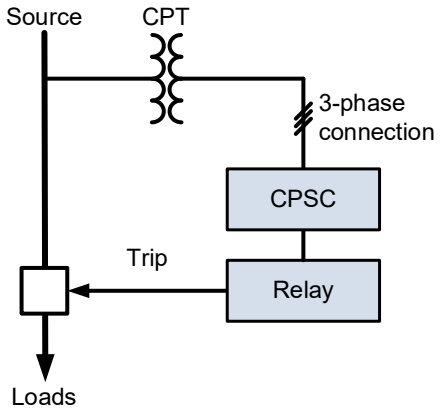
Electromechanical relay applications

- Capacitive trip device trips breaker
- Relays do not require a power source to operate
- Mechanical flags indicate contact operation

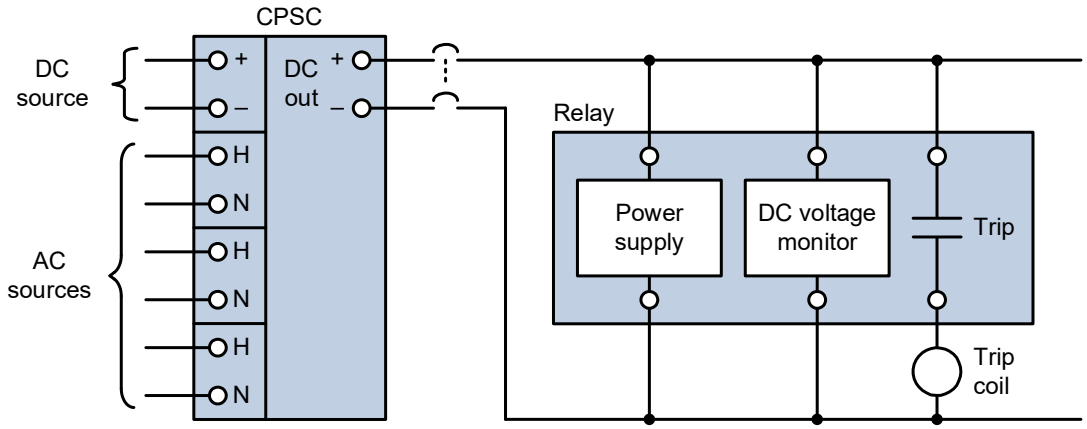


Complements digital relay upgrades

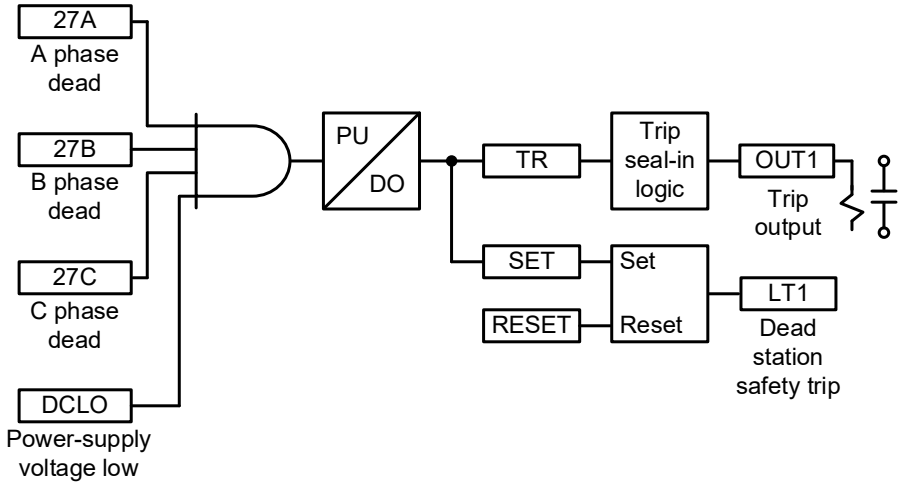
- Provides ride-through for momentary interruptions
- Can even replace capacitive trip units
- Keeps relay powered long enough to store event record



Safety schemes protect people and equipment



Safety schemes protect people and equipment

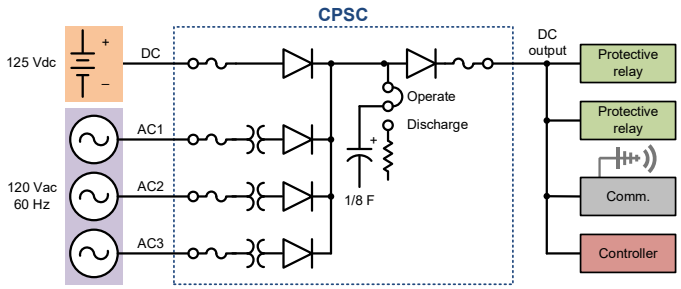


CPSC solves most auxiliary supply issues

- Capacitor provides ride-through during short circuits
- AC supplies are available if station is energized
  - Loss of station service
  - Loss of charger
- Capacitor provides momentary high current when needed
  - Hidden battery failures
  - Human error-caused battery disconnection
  - Out-of-service battery for testing or maintenance
- Black station safety logic can preemptively open breakers

Conclusion

- Reliability of dc systems is critical
- Substations contain many power sources
- Multiple unreliable sources can produce a reliable source
- Many applications could benefit from combining control power



Questions?