Impacts on the Power System

- Local protection
  » Protection of immediate equipment from damage
  » Minimize disruption of loads
    - Reduce duration when interrupted
- Larger system issues?
  » Impacts on stability of larger system
  » Potential for distant impacts

Some Consequences:
Substation Fire ... Evening News

3. 21. 2003
The Aftermath

Results of Transformer Fire
Generator Fault

Expensive Consequences for Protection Failure
What Events Require Protective Actions

• SYSTEM CONDITIONS
  » Faults
  » Abnormal operation

• ACTIONS
  » Trip breakers
  » Trip breakers after preset delay if fault remains
  » In some cases block tripping

Typical Response

• Detect that something has changed
• Identify what has happened
  » Local measurements
  » Communicated data
• Make decision (is this a problem or not)
  » Generate trip signal
  » 1-3 cycles to get to this point
• Breaker response (2-10 cycles)
Protection System

- Current and voltage transformers
- Relay
- Circuit breaker
- Communication system
- Coordinate with: Other relays, fuses, active controls

Protective Relay

- Piece of equipment whose function is to:
  - Detect defective or abnormal system conditions or detect defective apparatus
  - Initiate proper control response
- Common responses
  - Trip circuit breaker
  - In some cases close breaker
  - In some cases only issues alarm
- Generally a reactionary device
Relay Types?

- Legacy Relays:
  - Electromechanical (1900-present)
    - Single function and mission
  - Discrete digital and analog electronics (1970-1990s)
    - Multifunction, single mission

- Modern Relays
  - Microprocessor based
    - Multiple function and mission

Constraints

- **Sensitivity** - Must be able to detect faulted or abnormal conditions
- **Selectivity** - Accurately identify a problem, and only react if there is a problem
- **Reliability** - Must also be operate for a long time without acting, and then act properly
- **Speed** - React quickly to minimize damage
Impact of Response

- Faster response implies:
  - Less disruption of loads
  - Less energy at the point of fault --less damage
    - Smaller fireball
  - Faster reclosing -- Improved stability
- Coordination with other devices
  - Intentional delay

What are the inputs?

- Voltage
  - Step down for relay input
- Current
  - Step down for relay input
Modern Relays

- Microprocessor based relays

CT or VT → Signal Conditioning → Sampling and Conversion → Magnitude Phase Calc

Circuit Breaker → Trip Logic → Relay Algorithm

---

Redundancy

- Overlapping zones of protection are common

---

Introduction to Protective Relaying
Spring 2016
<table>
<thead>
<tr>
<th>Overlapping Zones</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Backup in case relay or breaker fails</td>
</tr>
<tr>
<td>• Time delay if out of primary zone</td>
</tr>
<tr>
<td>• Often more sensitive in secondary zone</td>
</tr>
<tr>
<td>• Coordination is a key issue</td>
</tr>
</tbody>
</table>

*Introduction to Protective Relaying*  
Spring 2016