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
Protection System

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

Must be able to detect faulted or abnormal conditions—sensitivity

Accurately identify it a problem, and only react if there is a problem—selectivity

Must also be operate for a long time without acting, and then act properly—reliability

React quickly to minimize damage—speed
Typical Response

?- Time to detect problem, identify, make decision, and act typically 2-3 cycles (varies with application, can be sub-cycle)

?- Breaker response often 1-3 cycles (solid state breakers faster)
Modern Relays

? Microprocessor based relays

Diagram:
- CT or VT
- Signal Conditioning
- Sampling and Conversion
- Magnitude Phase Calc
- Circuit Breaker
- Trip Logic
- Relay Algorithm
Modern Relays

? Microprocessor based relays

? Sample measured data and compute:
  » RMS voltage or current
  » Sequence components (especially 0 or 2)
  » Phase Angle
  » Impedance or Admittance
  » Frequency
Evaluate Calculated Data Based on Algorithm

- Overcurrent
- Time-overcurrent/Inverse time-overcurrent
- Over/under voltage
- Real or reactive power
- Impedance (distance protection)
- Frequency
- Reverse power
Evaluate Calculated Data Based on Algorithm

- Harmonic content (often used for blocking)
- Magnitude of negative sequence term
- In some cases transient responses used
- Direction to fault
- Fault location
- Breaker failure
- Series faults (line open)
- Combined series/ground faults
Components that are Protected

- Lines (transmission and distribution)
- Buses
- Transformers
- Motors
- Generators
- Capacitors/reactors
- System stability
Overlapping zones of protection are common.
Overlapping Zones

- Backup in case relay or breaker fails
- Time delay if out of primary zone
- Often more sensitive in secondary zone
- Coordination is a key issue
Differential Protection

- Differential protection
- Compare current into and out of device
- Can be very sensitive
- Multiple legs in and out
- Phase shifts in transformers
- Inrush currents
- Problem with longer distances
Role of Communication

? Line protection far faster when can compare notes with other end of line

? Can locate zone fault is in

? Need to have adequate back-up in case communication is lost (often distance or impedance)

? Redundancy--does communication go as a result of the fault?