Remedial Action Schemes (RAS)

Presented by

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Hands-On Relay School
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Overview

- What is RAS?
- Why is RAS Needed?
- Types of RAS
- Composite of a RAS Scheme
- RAS Design
- RAS Testing
What is a RAS?

- **Synonymous Acronyms**
  - RAS – Remedial Action Scheme (WECC)
  - SPS – Special Protection Scheme (NERC, others)
  - SIPS – System Integrity Protection Scheme (IEEE)

- Automatic protection system designed to quickly detect abnormal predetermined system conditions and takes a predefined action to prevent a system problem

- Take corrective actions other than and/or in addition to the isolation of faulted components to maintain system reliability
What a RAS is not?

- Fault conditions that must be isolated with standard relaying schemes
- Underfrequency or Undervoltage Load Shedding
- Out of Step Relaying
RAS or Other Alternative?

- Responds to low probability events in the system
- Increases path capacity without building more power lines
  - A $1m RAS in place of a $50-$200m transmission line
  - Operating transfer capability on a path could quadruple with a RAS
- Helps balance load and generation after a loss of one or the other
- Increases overall system reliability
Local vs Wide Area

**Wide Area Protection Scheme (WAPS):** A Remedial Action Scheme whose failure to operate WOULD result in any of the following:

- Violations of TPL – (001 thru 004) – WECC – 1 – CR - System Performance Criteria
- Maximum load loss $\geq 300$ MW
- Maximum generation loss $\geq 1000$ MW

**Local Area Protection Scheme (LAPS):** A Remedial Action Scheme whose failure to operate WOULD NOT result in any of the above.

Basically, Local RAS does not impact bulk transmission system whereas Wide Area RAS does.

Wide Area RAS requires higher reliability requirements and a more thorough review from WECC RASRS subcommittee.
With series capacitors installed on the Landon-Walnut Grove line, there is a concern of SSR problems on the generators if radial. Local RAS scheme in place to bypass series capacitors if generating while radial.
• Loss of 2 units at Palo Verde while running above 2550MW would cause instability to the Calif/Oregon Inter-tie (COI)
• Required load shed of at least 120MW to mitigate
Composite of a RAS Scheme

Problem to Mitigate (Mitigate Definition: Reduce or Eliminate a Problem)
- Thermal (fast: seconds or minutes)
- Voltage Instability (faster: cycles or seconds)
- Transient Instability (fastest: 8-30 cycles)

Arming Condition
- Line Loading
- Generation Output
- Line out of Service

Trigger Condition
- Loss of Line
- Loss of Generation

Operate (What the Scheme does to mitigate problem)
- Cap Insertion, Gen Drop, Load Shed, Cap Bypass
Thermal Overload

- Result from excessive currents flowing through transmission circuits caused by heavy loads
- Can cause overheating, line sags, and loss of conductor strength
- These RAS schemes can take sec/min rather than a few cycles
- Examples of mitigation include backing generation or load shedding
Voltage Instability

When a line loaded above it’s Surge Impedance Level (SIL), it acts like a reactor. This pulls the voltage down and puts the system at risk of a voltage collapse if loading increases.

- The reactance causes voltage problems before resistance heating causes thermal problems.

Examples of mitigation include shunt cap insertion or gen drop.
**Problem to Mitigate:** Thermal overload on Path 4 and voltage stability problems on neighboring busses

**Arming Condition:** Load on Buckeye-Jayhawk line exceeds 800MW

**Trigger Condition:** Loss of Buckeye-Jayhawk Line

**Operate Condition:**
- Insert shunt cap within 10 cycles
- Trip Buckeye Unit 1 within 60 cycles
Disturbance which does not allow a generator to deliver its power into the network. (i.e. sudden line outages)

Power then absorbed by generator resulting in sudden acceleration of the rotor and eventually cause damage of the generator

Examples of mitigation include fast gen drop or use of braking resistor
<table>
<thead>
<tr>
<th>ARMING Condition</th>
<th>Line Status</th>
<th>Flow</th>
<th>Possible Violation/Study</th>
<th>Trigger Condition</th>
<th>Action - Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAS 1-1</td>
<td>CO-SI in Service Series Capacitors in CHO-PR in service CHO-PP in service</td>
<td>CHO-PR + 14.9% of CO-SI &gt; 566</td>
<td>Various (see below) ABB Case (Transient Stability) Thermal Case 1 (ALIS) Thermal Case 9 (SPV-Vall IOS) Thermal Case 10 (SPV-McK IOS) Thermal Case 11 (SPV-Greenlee) Thermal Case 12 (SPV-Luna IOS)</td>
<td>CO-SI Trip</td>
<td>FLT + 15 cycles: Insert PP Shunt Capacitor FLT + 15 cycles: Insert PB Shunt Capacitor FLT + 1.5 second: Trip CGS Unit if CO932 and CO935 open</td>
</tr>
<tr>
<td>RAS 1-2</td>
<td>CO-SI in Service Series Capacitors in CHO-PR in service CHO-PP in service</td>
<td>CHO-PR + 7.6% of CO-SI &gt; 555</td>
<td>Various (see below) ABB Case (Transient Stability) Thermal Case 2 (CO-SUF IOS)</td>
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<tr>
<td>RAS 1-3</td>
<td>CO-SI in Service Series Capacitors in CHO-PR in service CHO-PP in service</td>
<td>CHO-PR + 19.1% of CO-SI &gt; 576</td>
<td>Various (see below) ABB Case (Transient Stability) Thermal Case 3 (CO-SPV IOS)</td>
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<td>RAS 1-4</td>
<td>CO-SI in Service Series Capacitors in CHO-PR in service CHO-PP in service</td>
<td>CHO-PR + 18.9% of CO-SI &gt; 565</td>
<td>Various (see below) ABB Case (Transient Stability) Thermal Case 4 (CHO-PR IOS)</td>
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<td>RAS 1-5</td>
<td>CO-SI in Service Series Capacitors in CHO-PR in service CHO-PP in service</td>
<td>CHO-PR + 20% of CO-SI &gt; 576</td>
<td>Various (see below) ABB Case (Transient Stability) Thermal Case 5 (CHO-PP IOS)</td>
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<td>RAS 1-6</td>
<td>CO-SI in Service Series Capacitors in CHO-PR in service CHO-PP in service</td>
<td>CHO-PR + 21.9% of CO-SI &gt; 573</td>
<td>Various (see below) ABB Case (Transient Stability) Thermal Case 6 (CHO-SAG IOS)</td>
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<td></td>
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<tr>
<td>RAS1-7</td>
<td>CO-SI in Service CHO-PR in service CHO-PP in service</td>
<td>CHO-PR + 8.5% of CO-SI &gt; 582</td>
<td>Various (see below) ABB Case (Transient Stability) Thermal Case 8 (CHO-SUF IOS)</td>
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<tr>
<td>RAS 1-8</td>
<td>CO-SI in Service Series Capacitors in CHO-PR in service CHO-PP in service</td>
<td>CHO-PR + 7.8% of CO-SI &gt; 555</td>
<td>Various (see below) ABB Case (Transient Stability) Thermal Case 2 (CO-SUF IOS)</td>
<td>CHO-SUF Trip</td>
<td>FLT + 15 cycles: Insert PP Shunt Capacitor FLT + 15 cycles: Insert PB Shunt Capacitor</td>
</tr>
</tbody>
</table>
Design Components

- Sensing
  - CTs/PTs, Transducers

- Input/Outputs
  - Breaker status, trip coils, control outputs, etc.

- RAS Controllers
  - Relays, PLCs, DCS

- Communications
  - Bandwidth to meet time constraints
  - Low data error
  - High availability

- Redundancy, Redundancy, Redundancy!
Panel Layout Example

- RAS A
  - Disable Switches
  - FT-19 CUTOFF BLADES

- RAS B
  - SELECTOR SWITCHES
  - TEST SWITCHES

- LOCKOUTS
Panel Layout Example

- All cables redundant
- Power supply fusing redundant
- RAS A wiring on one side of panel, RAS B wiring on the other

RAS A DC

RAS A Control, Alarms, Status

RAS A Currents & Potentials

RAS B DC

RAS B Control, Alarms, Status

RAS B Currents & Potentials
• Relays connected in either LAN network or G.703 ring

• Relays can exchange data with any other relay in its network or ring
RAS Example - Review

- Problem to Mitigate
- Arming Condition
- Trigger Condition
- Operate (Method of Mitigation)
RAS Example – Problem to Mitigate

Problem to Mitigate

• Voltage dip at DB 230kV bus and neighboring busses
• Casa Grande 230/69kV transformer overload

Fault occurs on DBG-Santa Rosa 230kV line

The only outlet for DBG generation is 100MVA Casa Grande 230/69kV transformer

Casa Grande – Saguaro 230kV line
Initially out of service (IOS)
RAS Example – Arming Condition

**Diagram Description:**
- **GROSS DBG OUTPUT THRESHOLD (MW)**
- **TERMINAL VOLTAGE (kV)**

**Legend:**
- **RAS Armed**
- **CT1 trip**
- **CT1&CT2 trip**

**Regions:**
- **REGION 1**: CT1 or CT2 ARMED TO TRIP
- **REGION 2**: CT1 and CT2 ARMED TO TRIP
- **NOT ARMED**

**Key Values:**
- Thresholds for different voltage ranges and corresponding RAS conditions.
RAS Example

TOTAL MW SIGNAL

TERMINAL VOLTAGE SIGNAL

DCS

GENERATING IN OPERATING REGION

PLC

ARMED SIGNAL TO SEL321 RELAY
Trigger Condition
• Fault on the Santa Rosa Line

Operate – Method of Mitigation
• Gen Drop
Functional Testing

- **Acceptance Checks**
  - Verify the functionality of the relay inputs/outputs

- **Scheme Checks**
  - Verify the wiring and all new physical connections to controllers/relays
  - Verify operation of lockouts when trip outputs are initiated

- **Logic Testing**
  - Verify operation of relay settings and logic of each relay

- **End-to-end Testing**
  - Verify data transfer between relays
  - Initiate trigger condition and verify operation and timing
**Timing Test Results**

Average Time Elapsed from Santa Rosa Line Fault to Generator Breaker Trip:
- RAS A = 5.8 cycles
- RAS B = 6.0 cycles

*Indicates Timing Test Verified*
Remedial Action Scheme Reliability Subcommittee (RASRS)

- Originally a task force in 1985
- In 2005, task force was designated a subcommittee reporting to WECC
- Committee consists of knowledgeable representatives from several region utilities with backgrounds in communication, automation, planning, operations, and relaying.
- Reviews the RAS designs to ensure reliability and no single points of failure that would result in Bulk Electric System performance outside of WECC performance limits
QUESTIONS