Generator Breaker Failure Applications

Christopher Dall, Dennis Tierney

Calpine Corporation
Contents

- Overview of Standards discussing breaker failure for generator applications
- Case studies
  - CT location
  - Flashover protection
  - Noise and instantaneous re-trip
  - Breaker lockouts
  - Current detectors (exciters online or offline)
Overview of BF for generator applications

- Two main standards to consider:
  - IEEE Std C37-102
  - IEEE Std C37-119
- Breaker failure has two classifications:
  - Failure to Trip (e.g. mechanical issues)
  - Failure to Clear (e.g. loss of dielectric, flashover)
Overview of BF for generator applications

• Other situations not classified as Breaker Failure (C37.119)
  – Loss of dielectric
  – Contact flashover

• Given the potential damage to a generator these situations should be considered in a breaker failure scheme.
Minimum fault current scheme (C37-119)
Overview of BF for generator applications

Flashover protection scheme (C37-102)

**Breaker open**

**GSU XO Bushing Current Detector**

Generation Protective Trip
Breaker Failure Initiate

**Breaker Closed**

Current Detector

52b

50G

BFI

52a

50BF

Breaker Failure Timer

62

BFT

Breaker Failure Trip
Case 1 – Current transformer location

- Consider all possible fault locations...
Case 1 – Current transformer location

Generator Circuit Breaker CTs

Generator Line Side CTs

Generator Neutral CTs

50BF

50BF
Case 2 – Flashover protection

- After the BFI has de-asserted necessary to re-enable breaker failure scheme for flashovers

Diagram showing:
- GSU High Side Currents
- GSU Low Side Currents
- GSU Neutral Current
Case 2 – Flashover protection

*Current detector must be set sensitively enough to declare breaker failure
Case 2 – Flashover protection

• Consideration for flashover protection:

1. Use separate 52a and 52b contacts (i.e. do not invert 52a)
2. Implement a 52 contact disagreement scheme
3. Ring bus and breaker and a half schemes should require both 52b contacts to enable
   • Susceptible to tripping for transmission LG faults
Case 3 – Noise on Breaker Failure Initiate

- For latched BFI signals or instantaneous re-trips, noise can cause nuisance tripping.
Case 3 – Noise on BFI and instantaneous re-trip

*62BFI + 62BF = total breaker failure time
Case 4 – Circuit breaker lockouts

- Circuit breakers may have alarms which will block them from opening
  - Low spring charge
  - Low gas (SF6) pressure
- In the event of a protective trip we must declare a breaker failure if we know the circuit breaker is blocked from opening.
Case 4 – Circuit breaker lockouts
Case 5 – Current detector pickup

- Depending on the system conditions when the generator circuit breaker is required to open the currents can vary drastically
  - System fault
  - Problem at minimal load
- If the breaker fails and the turbine and exciter have been tripped the generator will be motored potentially causing serious damage to the rotor, stator and turbine.
Case 5 – Current detector pickup

- Example of unbalanced currents on generator after breaker failure
**Case 5 – Current detector pickup**

**GSU High Side Currents**
- $I_a := (I_1 + I_2 + I_0) \cdot I_{bsys}$
- $I_b := (I_1 \cdot a^2 + I_2 \cdot a + I_0) \cdot I_{bsys}$
- $I_c := (I_1 \cdot a + I_2 \cdot a^2 + I_0) \cdot I_{bsys}$

**GSU Neutral Currents**
- $I_{X0} := 3 \cdot I_0 \cdot I_{bsys}$

**GSU Low Side Currents**
- $I_A := (I_1 \cdot (1 \angle -30^\circ) + I_2 \cdot (1 \angle 30^\circ)) \cdot I_{base}$
- $I_B := (I_1 \cdot a^2 \cdot (1 \angle -30^\circ) + I_2 \cdot a \cdot (1 \angle 30^\circ)) \cdot I_{base}$
- $I_C := (I_1 \cdot a \cdot (1 \angle -30^\circ) + I_2 \cdot a^2 \cdot (1 \angle 30^\circ)) \cdot I_{base}$

$I_{bsys}$ – base current on system voltage
$I_{base}$ – base current on generator voltage
Case 6 – Detection with exciter online

- If the exciter remains online after the failed GCB is opened then the current magnitudes can be undetectable on the GSU high voltage side
Case 6 – Detection with exciter online

Minimum Pickup for 50BF in switchyard relay

Measured current

GCB Trip Signal

SWYD CB Opens

Current (referred to 18 kV)

Time

A (18 kV @gen)

A (345 kV @SWYD)

Min 50BF Pickup

Measured current

GCB Trip Signal

SWYD CB Opens

Current (referred to 345 kV)
Case 6 – Detection with exciter online

Measured current

Minimum Pickup for 50BF in switchyard relay
Case 6 – Detection with exciter online

Reverse power element pickups

GCB Trip Signal

SWYD CB Opens

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<th>Time</th>
<th>Generator MW/MVAR</th>
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<td>Reverse power element pickups</td>
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<td>18.0</td>
<td>Reverse power element pickups</td>
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</table>
Case 6 – Detection with exciter online

Reverse power element pickups

Graph showing generator MW/MVAR over time with markers for GCB Trip Signal, Exciter Tripped, and SWYD CB Opens.
Case 6 – Detection with exciter online

52a/b Disagreement -> Reverse Power Timer 62RP
LCI Start 32
Reverse Power 52b
Breaker open

BFT
Breaker Failure Trip

62BF
Breaker Failure Timer
Conclusions

• Locate Current transformers on the circuit breaker

• Desensitize the scheme to noise

• Special considerations for flashover protection

• Current detectors based on motoring events

• Use of reverse power element to detect failure
Conclusions

• Power plant operators should have defined procedures in the event that a breaker failure of a GCB goes undetected by the protection.