Advanced Failure Detection and Handling in Power Management System

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Content

• Introduction

• Advanced Generator Supervisor (AGS)

• Results from full scale tests.
Single bus operation

Running power plant with closed bus ties in a diesel electric installation.

- Less generators connected.
- More optimum load on running engines.
  - Environment.
  - Fuel and maintenance cost.

➢ A single failure must not propagate to total blackout!
DP incidents

International Marine Contractors Association (IMCA).

DP incident reports.

- In the period 2000 – 2006 appr. 10-24% of DP loss of position incidents was caused by power generation.
Power plant safety hierarchy

1. Primary protection system in breakers and switchboards.

2. Power management system and blackout prevention / consumer control system.

3. Loadsharing monitoring system.

- Level 2 & 3 shall prevent trip of generators, tie-breakers or consumers by primary protection system.
Power Management System (PMS)

- Load sharing. Symmetric and asymmetric.
- Reactive load sharing (power factor control).
- Load dependent start and stop.
- Alarm changeover.
- Blackout reconnection.

- Fast consumer load limitation & reduction.
- Close interaction with DP and thruster control systems.

- Signal verification.
  - Measurement validation, calculation of illegal values.
  - Breaker position and kW validation.
- Redundancy and segregation.
Advanced Generator Supervisor (AGS)
Advanced Generator Supervisor (AGS)

- IO reading & verification
- Power Management
- AGS
- Alarm & trip
- DG 1
- DG 2
- Power Management
- AGS
- Alarm & trip
- DG 3
- DG 4

[Diagram showing AGS integration with power management and IO reading & verification blocks, linked to DG 1, DG 2, DG 3, and DG 4 with alarm & trip signals.]
The goal of AGS is to detect and isolate generators with faulty speed or voltage control system.

- Avoid full or partial blackouts due to such failures.
- Be able to operate with closed bus-ties to reduce the number of generators on line => less fuel consumption and emissions.
Advanced Generator Supervisor (AGS)

AGS consists of two main functions:
- Monitoring of speed control system (active load sharing).
- Monitoring of voltage control system (reactive load sharing).

AGS is an expansion of the Power Management System.
Advanced Generator Supervisor (AGS)

• AGS interact with:
  • Fast heavy consumer load reduction system
  • Dynamic Positioning system (DP).

• AGS is available on:
  • New deliveries
  • Midlife upgrades of older deliveries.
Advanced Generator Supervisor (AGS)

IO reading & verification

Power Management

AGS

Alarm & trip

DG 1

DG 2

DG 3

DG 4

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Advanced Generator Supervisor (AGS)

- AGS continuously compares measured values with expected values calculated from a mathematical model of the system to detect which engine has a fault condition.

- First level of deviation:
  - Start standby generator(s) and give an alarm.

- If the deviations exceeds further:
  - Trip the faulty generator.
Advanced Generator Supervisor (AGS)

Available speed control modes

- Compensated droop
- Fixed droop
- Isochronous mode.

Available loadsharing modes

- Symmetric
- Asymmetric
  - Controlled from PMS in compensated droop.
  - Base load / MW control when controlled by an external system in isochronous or fix droop mode.
Speed control

Typical failures:

• Generator developing too high load. Caused by e.g. governor or actuator failures, feedback failure or PMS control signal failure to the governor.

• Generator not developing required load. Caused by e.g. governor failure, clogged fuel filter or other errors in prime mover.

Failure check based on:

• Net frequency
• Generator kW
• Engine fuel rack position.
Voltage control

Typical failures:

- Over excitation. This can be caused by e.g. loss of voltage feedback to the AVR.

- Under excitation. This can be caused by e.g. AVR malfunction.

Failure check based on:

- Net voltage
- Generator kVAR
- Generator field current.
AGS signal flow

1. Measured generator loads and frequency
2. Droop/Isoch mode, loadsharing modes and breaker positions
3. Total net load and net frequency
4. Total net reactive load and net voltage
5. Speed control reference values
6. Reactive load control reference values
7. Estimated generator load and net frequency
8. Estimated generator reactive loads, field currents and net voltage
9. Voltage control error detection
10. Alarms
11. Generator trip
12. TB trip
Results from full scale test.
Without AGS, Speed control failure.
4 generators online, isochronous mode, appr. 30% load
One generator forced to increase load.

-> Trip of all 3 healthy generators by breaker protection!
With AGS, Speed control failure.

4 generators online, droop mode, appr. 30% load
One generator forced to increase load.

Net frequency
Faulty generator kW
Healthy generators kW
With AGS, Speed control failure.

2 generators online, droop mode, appr. 30% load. One generator forced to increase load.
With AGS, Speed control failure.

2 generators online, droop mode, appr. 30% load. One generator forced to decrease load.
With AGS, Speed control failure, Isochronous
2 generators online, isochronous mode, appr. 30% load. One generator forced to increase load.
With AGS, Speed control failure, Asymmetric load
2 generators online, droop mode, appr. 30% load.
One generator forced to increase load.
With AGS, AVR failure.

4 generators online, droop mode, appr. 30% load. One generator with over-excitation.
Conclusion

Full scale tests shows that a model based failure handling system like AGS will work in all the commonly used operation modes.
Thank you for your attention!