Power Management Systems for Offshore Vessels

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Transocean

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Power Management Systems for Offshore Vessels

Dynamic Positioning Conference

Lew Weingarth, *Transocean*

Importance of Power Plants

- Current rates for rigs > $500,000 / day
- Power plant reliability affects client cost and drilling contractor revenue
- Power plant failures create costlier downtime than DP faults
- Often twice as much time spent convincing everyone that power plant is fixed than is required to fix power plant
Typical DP Rig Power System

- State-of-the-art drilling rig costs
  - $400M to $900M USD
  - 2 years to build

- DP rig power plant configurations
  - Single / dual bus (6 thrusters)
  - Dual bus (8 / 17 thrusters)
  - 18 configurations in Transocean
  - Dozens of configurations in the industry
Example DP Rig Power System
Cost of DP Incidents

- High costs
  - Loss of revenue / reputation
  - Delayed production
  - Risk to personnel, equipment
  - Potential environmental impact
- Reduction of DP incidents – major focus
- Power plant faults – main cause
IMCA statistics for 2007 DP Incidents (reproduced courtesy of IMCA DP Station Keeping Incident Report 2007)
DP Power Plant Faults

- Individual equipment faults addressed with maintenance, procedures, and redundancy
- Common-mode faults often end in blackout (limited protection)
PMS for DP Power Plants

• Other industries have even higher downtime costs and an even higher focus on power plant reliability
• Sophisticated simulation reduces installation time
• Industrial grade equipment provides high reliability
PMS for DP Power Plants

- Industrial grade equipment built with MIL-SPEC components provides high reliability
- Detection of impending failure rather than detecting failure improves reliability
Proposed Solution

- Local protection
  - Protection and controls
  - Communication

- System protection
  - Protection and controls
  - Communication
  - Engineering station
Proposed Solution

- Common-mode faults
- Design verification
- Security
- Reliability
Proposed System

GPS Satellite

Satellite Clock

System Protection

POWERMAX®

HMI

RTAC

SVP

Status and Control

Relays

11 kV Bus A

Tie Breaker

11 kV Bus B

Local Protection
Local Protection Block

- Generator protection and control
  - Power – P & Q
  - Differential
  - Loss of excitation
  - Under- and overvoltage
  - Under- and overfrequency
- Synchrophasor data collection
System Protection Block

• Power management system
  ♦ Load dependent start / stop
  ♦ Generator control and order selection
  ♦ Blackout start / recovery

• Engineering diagnostics
  ♦ SOE / ER
  ♦ HMI
Communications Options

- Synchrophasors
- Protocols
  - DNP3 / Modbus®
  - IEC 61131
  - MIRRORED BITS® Communications
  - IEC 61850
- Fiber optics
## Sequence of Events

<table>
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<tr>
<th>Time</th>
<th>Equipment</th>
<th>Description</th>
<th>State</th>
<th>Device</th>
<th>Element</th>
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**SER Viewer**

**ER Autoarchiving**
Additional PMS Features

- Synchrophasors
- Flexible synchronizer
- Arc-flash protection
- Additional protection
  - Bus, transformer, and feeder
  - Cable and motor
Common-Mode Faults

- Fuel / actuator
- Governor
- Exciters
- Other faults

Frequency (Hz)

- 61.8 Hz No Load
- 60.9 Hz 50% Load
- 60.0 Hz 100% Load
- 60.0 Hz 50% Load

Load

- 0%
- 50%
- 100%

3% Droop
Relay + Arc-Flash Detection = Most Reliable and Economical Solution

Fault Current

Self-Testing Sensors

Bare Fiber Loop

Point Sensors

Point Sensors
Example Report: Arc-Flash Fault
Arc-Flash Mitigation Solution

Light Sensor

Current Input

Arc-Flash Protection
Arc-Flash Mitigation Solution

- Replace relays
- Revise coordination / protection
- Use proper PPE
- Install warning labels
Automation Controller (RTAC)

**acSELerator® RTAC**
- Offline configuration
- Device definition
- RTAC firmware manager
- Custom logic programming

**Web Server**
- Communications state
- System diagnostics
- User administration
- Network configuration
- Alarm panel
- SER reports
- Security logs
Engineering Access

DNP3, Modbus, SEL, Mirrored Bits, IEC 61850, Synchrophasors

SCADA

Relays
Present Application Data Visualization
Detect and Respond to Power Oscillations

- Amplitude = 32.71
  - Damping Ratio = 8.9%
  - Frequency = 0.263 Hz
- Amplitude = 16.74
  - Damping Ratio = -0.76%
  - Frequency = 0.258 Hz
- Amplitude = 42.02
  - Damping Ratio = -3.22%
  - Frequency = 0.232 Hz

Line Trip

System Separation

Damping Ratio < 10%

Negative Damping Ratio

Damping Ratio < -3%
Differential Protection

- Blocking scheme
- High impedance
- Low impedance
Model Development

Real-Time Simulator

Power System Model

Analog Inputs V, I

Digital Inputs
CB Contacts

Digital Output
All the Protection Trips From Relay

PMS System

Protection Logic
Model Development

- Load flow
- Short circuit
- Motor starting
Model Validation

- Load shedding
- Exciter response curve
- Governor response curve
- Controls – power factor or VARs, etc.
System Analysis

- Normal system operation
- Black start
- Exciter faults
- Governor faults
- System faults (bus / transformer)
- Contingency
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<th>Component</th>
<th>Observed MTBF (years)</th>
<th>Unavailability (multiply by $10^{-6}$)</th>
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Conclusion

✓ Expandable and highly reliable system
✓ Communications options: synchrophasors, IEC 61850, Modbus / DNP3, MIRRORED BITS Communications
✓ Design verification and documentation
✓ Factory acceptance test with RTDS
Conclusion

- System / generator protection
- Arc-flash protection
- Flexible synchronizer
- Security
- Engineering station
- Analysis tools: SOE, ER
- Training and on-site support
Questions?