# GENERATOR AUXILIARIES

Zachary R. Behrens, PE
MWH Global
Hands-On Relay School 2016

# Summary

Protective relays are only a portion of what is necessary to keep generators operating and healthy. This lecture will provide students with an overview of synchronous generator auxiliary systems. Areas of study include: governors, exciters, machine condition monitoring, lube systems, cooling systems and more.

# Primary Systems

- Governors
  - Control Speed
- Exciters
  - Control Voltage
- Machine Condition Monitor (MCM)
  - Monitor Mechanical Systems
- Mechanical Auxiliary Systems
  - Lubrication, Cooling, Control
    - Oil, Water, Gas

# Governors

- Primary Functions:
  - Speed Regulation
  - Starting and stopping
  - Synchronization
  - Loading and unloading the unit

# Governors

- Types of Governors:
  - Mechanical
  - Electronic
  - Custom Digital Systems
  - PLC-based Systems

# Governors

- Start-Up Operations:
  - Control and check auxiliary system
  - Start rotation
  - Build speed to rated frequency
  - Synchronize

# Governors

- Synchronizing Operations:
  - Match unit frequency to system frequency
  - Adjust for bus slip
  - Control phase angle
  - Match unit voltage to system voltage
    - If not done by exciter
  - Close generator circuit breaker
    - Can take the place of additional synchronizer equipment

# Governors

- Online Operations:
  - Speed regulation
  - Power regulation
  - Water flow regulation
  - Loading and unloading
  - Islanded

# Governors

- System Failures:
  - Speed sensors
  - Gate position sensors
  - Oil pressure
  - Oil level

# Exciters

- Primary Functions:
  - Generator Voltage Control
  - Maintain Synchronism
  - Maintain Operation within Generator Capabilities
- Secondary Functions:
  - Field Flashing and Field Discharge
  - VAR and PF Control
  - Synchronizing

# Exciters

- Types of Exciters:
  - Rotating (Permanent Magnet Generators)
  - Externally-Supplied (Power System or MG Set)
  - Shunt-Supplied (From Generator Terminals)
    - Brushless
    - Static

# Exciters

- Generator Voltage Control Operations:
  - Control field current
  - Automatic Voltage Regulation (AVR)
    - Control voltage at generator terminals
  - Power System Stabilizer (PSS)
    - Dampen local and system frequency oscillations

# Machine Condition Monitoring

- Primary Function:
  - Mechanical Systems Monitoring
  - Data Collection Software and Controller for to Detect Unexpected Failure in the Early Stages
    - HMI
    - Alarming and Tripping
    - Trending Information
      - Vibrations
      - Orbital Plots
      - Stator and Rotor Roundness

# Machine Condition Monitoring

- MCM Typical Parameters:
  - Bearing Vibration (Runout)
    - X-Y Proximity Probes (Eddy Current)
  - Thrust Bearing Oil Film Thickness
    - Z Proximity Probe (Eddy Current)
  - Head Cover and Draft Tube Vibration
    - Accelerometers
  - Turbine Blade Tip Clearance
    - Proximity Probe (Eddy Current)

# Machine Condition Monitoring

- MCM Typical Parameters (continued):
  - Phase Reference
    - Once per revolution indication
  - Stator Frame Vibration
    - Velocity or accelerometer
  - Stator End Winding Vibration
  - Air Gap Detection
    - Distance between rotor and stator
    - Capacitive Sensors

# Machine Condition Monitoring

- MCM Typical Parameters (continued):
  - Stator Winding Insulation Deterioration
    - Small, High Frequency, Voltage Pulses
    - Partial Discharge
- Additional Parameters:
  - Wicket Gate and Blade Position
  - Bearing, Stator and Rotor Temperatures
  - Turbine Flow
  - Cavitation

# Oil Systems

- Primary Function:
  - Friction Reduction
    - Prevents wear
    - Removes heat
    - Improves efficiency
- Typical Oil Systems:
  - Bearing Lubrication and Cooling
  - Hydraulic Control
    - Governor

# Oil Systems

- Oil System Components:
  - Tank
  - Filter
  - AC and DC Pumps
  - Control, Distribution and Isolation Valves
  - Indication, Control and Protection Measurements
    - Pressure
    - Level
    - Flow
    - Temperature

# Cooling Systems

- Primary Function:
  - Heat Reduction
    - Improves efficiency
- Types of Cooling Systems:
  - Gas
    - Nitrogen, Hydrogen, etc.
  - Air
    - Fan, Natural Convection
  - Water
    - Heat Exchangers, Injection, etc.

# Cooling Systems

- Cooling System Components:
  - Air and Gas Cooling System
    - Isolation valves, pressure switches/transducers, regulators and piping, motors, pumps, compressors
  - Stator Cooling Water System
    - Isolation valves, pressure switches/transducers, regulators and piping
    - Directly Cooled Windings
      - Requires de-ionized and de-mineralized water to lower conductivity

# QUESTIONS?