Integrating Medium Voltage Switchgear Breakers into a Safety Instrumented Function

Dave Grattan PE, CFSE  
Sam Nicholson PE, EE  
S&B Engineers and Constructors, Ltd.
Topics:
1. Introduction
2. Motor Control & Protection
3. Failure Modes/ Mechanisms and Data
4. Functional Safety Applications
Introduction:

• SIF (Safety Instrumented Function) – Process
• Protective Relay System - Electrical

[Diagram: Sensor connected to Logic Solver, which is connected to 125 VDC Control Circuit and 52 AC Circuit Breaker (Air magnetic, vacuum, SF6). All connected to Connected Electrical Equipment.]
Introduction:

- Switchgear
- MCC
- Breaker
- Contactor
- Medium Voltage
Introduction:

• Breakers are tripped for:
  ➢ Hazard Prevention/Mitigation (Process) - SIS
  ➢ Fighting Class C (electrical) fires – FPS
  ➢ Isolate Electrical Faults – Protective Relaying
Motor Control & Protection:

• **Low-Voltage MCC**

![Diagram showing a Low-Voltage MCC (600 V Class)]
Motor Control & Protection:

• Medium-Voltage MCC
Motor Control & Protection:

• Medium-Voltage Switchgear

- MV Metal Clad SWGR (15 kV Class)
- Stab-in (Gas Insulated SWGR is bolt-in)
- AC Circuit Breaker (Air magnetic, vacuum, SF6)
- 52
- 125 VDC Control Circuit
- 49
- Protective Relay
- Stab-in
- Thermal Over-Load Relay
- Cable
- Motor

Motor Stab-in (Gas Insulated SWGR is bolt-in)
Failure Modes/ Mechanism:

• Contactors

- Fixed Contacts
- Moveable Contacts
- Contact Spring
- Opening Spring
- Solenoid
- Armature (moveable)

- Solenoid energized (contacts close)
- Solenoid de-energized (contacts open)
Failure Modes/ Mechanism:

• Vacuum Technology

Vacuum Bottle
Failure Modes/ Mechanism:

• Vacuum Contactor
Failure Modes/ Mechanism:

• Vacuum CB
Functional Safety Applications:

• Motor Control Systems
  ➢ Protective Relay
  ➢ SIF
  ➢ Manual (Handswitch)
  ➢ Starters and Drives and other controllers
Functional Safety Applications:

• Motor Control Systems

**Position your SIF to act directly on the breaker or contactor, between the contactor/breaker and other motor control systems.**
Functional Safety Applications:

- Fault Tree for Vacuum Contactor:

  TOP EVENT
  Probability SIF is Failed when Process Demand Occurs

  SENSOR
  LOGIC SOLVER
  UNDERVOLTAGE RELEASE
  CONTACTOR (ELECTRICALLY HELD)

Motor Starter
Functional Safety Applications:

• Fault Tree for Vacuum CB:

TOP EVENT
Probability SIF is Failed when Process Demand Occurs

SENSOR
LOGIC SOLVER
CIRCUIT INTEGRITY of SHUNT TRIP
SHUNT TRIP COIL
CIRCUIT BREAKER
125 VDC CONTROL POWER (to operate CB)
Switchgear Breaker
Functional Safety Applications:

• LOPA

• Secondary Means of Shutdown
  ➢ Extending proof-test interval
  ➢ Meeting HFT (Hardware Fault Tolerance) requirements
  ➢ Additional IPL (Independent Protection Layer)
QUESTIONS?: