Engineer It First – Before You Test It!

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Introduction

Design of a Protection & Control System

Protection & Control System Access

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Engineer to Test

Conclusion

Introduction

- The commissioning / testing of a Protection & Control System is the last step in the overall engineering process of system study, protection concept, design, purchase, build, and installation of such a system.
- The ability to test a legacy P&C panel was literally “built-in.”
- Legacy protection devices:
  - designed by manufacturers with testing considerations
  - provided test procedures & isolation recomendations in the documetation
  - or incorporated test link isolation as part of the mechanical design
  - or provide a drawout mechanism with built in shorting / isolation
  - or “D” – all the above.
- As P&C systems evolved and the industry deregulated, testing interfaces became optional from economic pressures.
- Modern protection devices:
  - designed by manufacturers with unit cost as primary driver
  - physical installation specifications and interface wiring
  - provide test procedures but no test isolation recomendations
  - user left to work out physical installation details
  - additional services offered for support or turn key projects

Design of a Protection & Control System

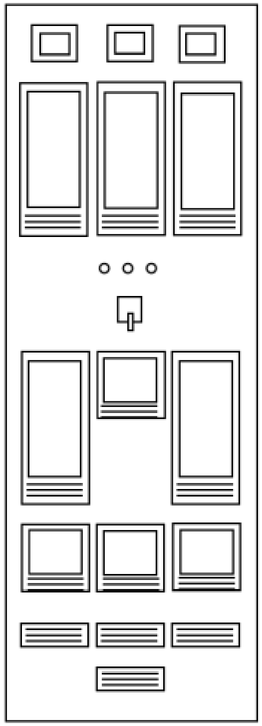
> “The Art and Science of Protective Relaying”, Wiley 1956, C. Russell Mason.

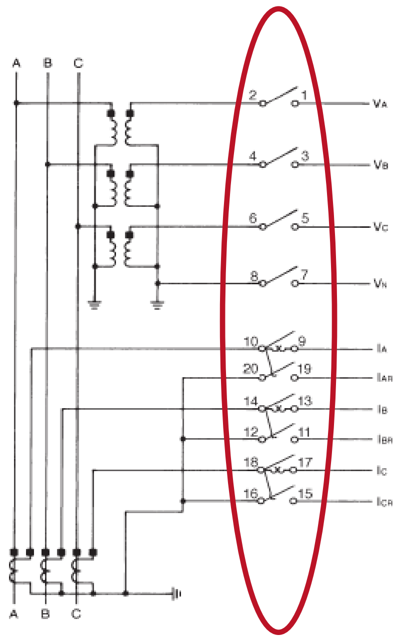
> E/M P&C Panels and Cubicles were “engineered” to fit their application.

> The ability to test and maintain these systems was a core requirement because they were serviced on a near annual basis.

> Engineers “learned” what was required for testing of these systems with project experience.

> Utility documents were maintained as “standards” for their applications with components and interfaces defined.





Design of a Protection & Control System

> Protection relays evolved; digital technology changed the “foot print” of the P&C system.

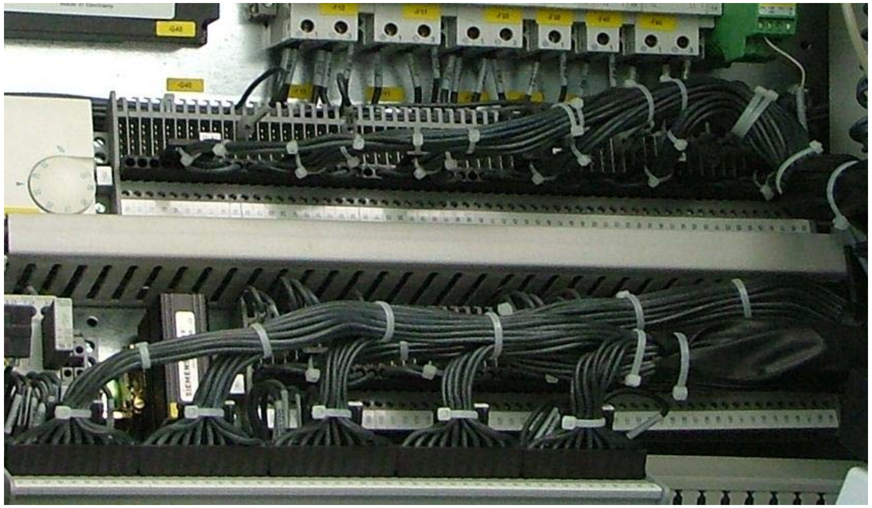
> Where an E/M relay averaged 18 wires per sq ft; the digital relay would average 46 wires per sq ft.

> Adoption of 19” rack mounting further increased wiring densities.

> Reduction in # of panels meant less control house space and cost savings.

> Drawings devolved to wiring connections only.

One digital feeder P&C pkg →



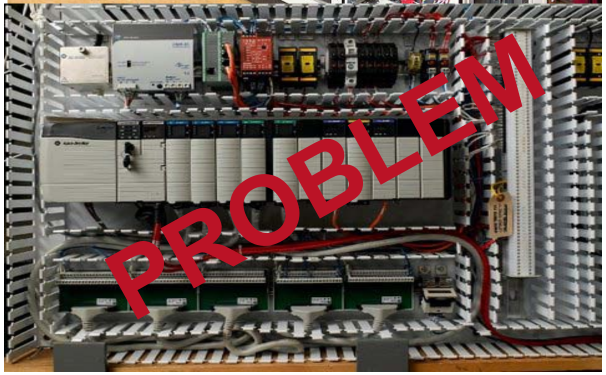
Protection & Control System Accessibility

- > Switchgear and MCC's are known testing issues
  - > Lack of isolation points for currents and voltages
  - > Some difficulty in isolating DC circuits
  - > Arc flash testing is often required
  - > Easier to rack out the CB or motor
- > Unwiring, temporary wiring, jumpers, incomplete documentation, and restoring the wiring become a major cost driver for maintenence of these systems.
- > Outage times are double or more of normal, testing mistakes are more frequent, testing focus is reduced, personnel safety decreased.
- > Maintenence Man-Hours and Outage time will far exceed the intial cost savings of not having proper testing blocks and interfaces.

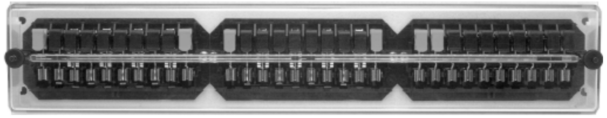
SOLUTION

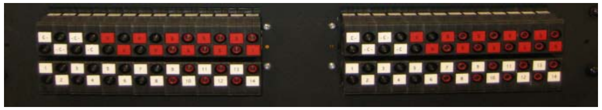
Protection & Control System Accessibility

- Use of 19” Rack Systems has increased wiring densities and limited access to IED’s for testing.
- Use of smaller form factors like DIN Rail Mounting also tend to increase wiring densities.
- Traditional E/M relays “forced” a certain degree of spacing that limited wiring densities.
- If no provision is made for testing access, these increased densities will require extended outages while temporary connections are made and unmade.
- These systems should be retrofitted to control maintenence costs over the life cycle of these P&C Systems.



SOLUTION >





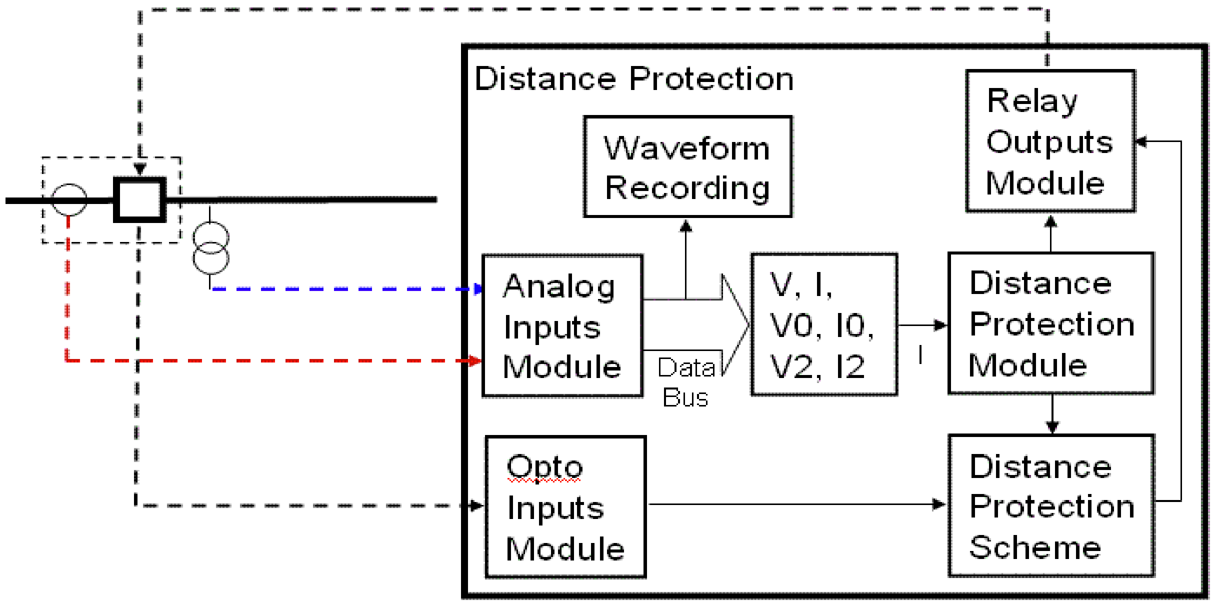
Protection & Control System Accessibility

- Control house footprints are shrinking
- Complete P&C systems are distributed in outdoor cabinets – making testing more challenging. (think reclosers)
- Digital relays and devices still have to be tested, especially those for the BES. (NERC/FERC)
- When testing is made difficult, shortcuts and omissions are made making “Murphy” very happy.
- Safety should be a priority, any CT circuit should be properly engineered for testing safely.
- A digital P&C system can have other testing pitfalls with their “all-in-one” multi-functional design.

Digital Protection Relays / Design Fundementals

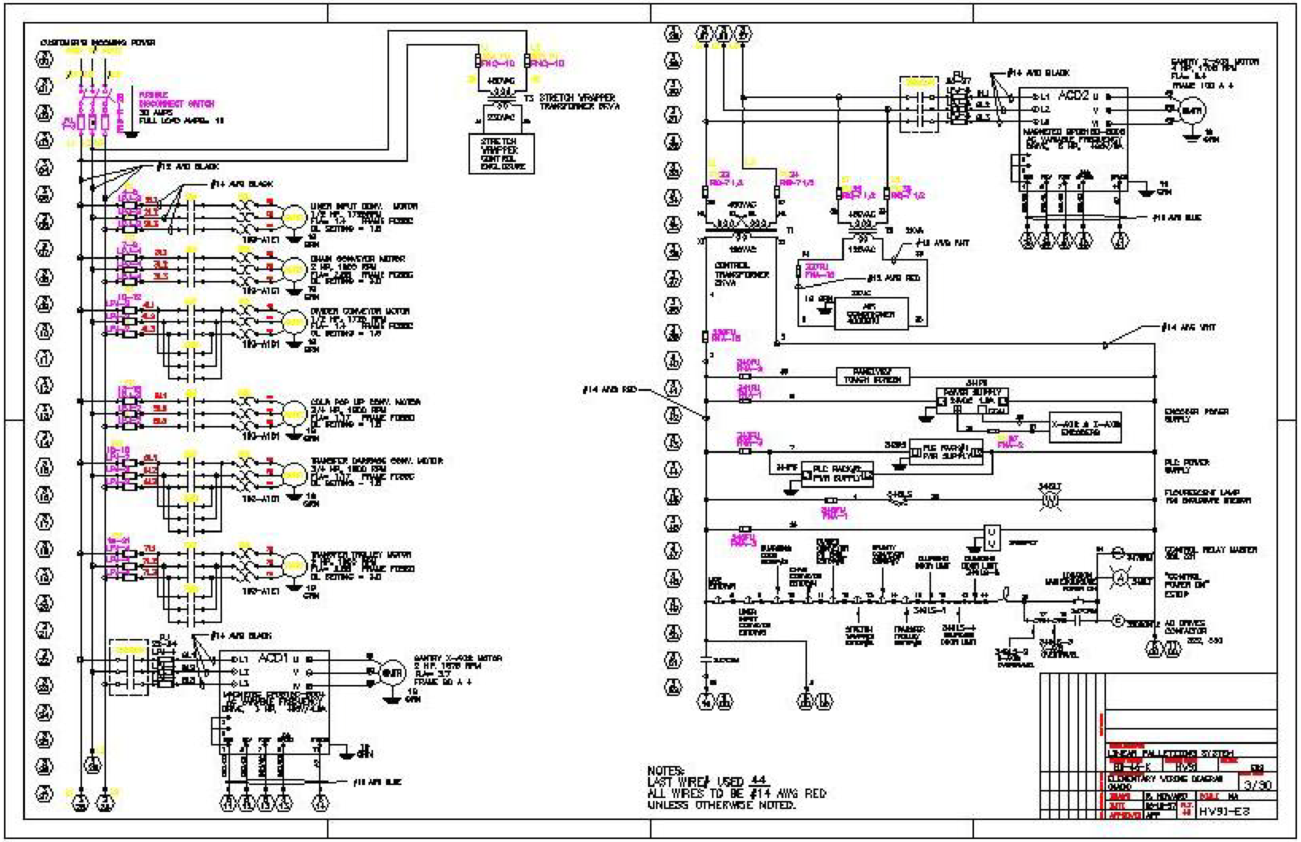
Digital Protection Relays are here to stay, they are:

> A purpose built computer, functionally modular in design, using a realtime kernal OS, with fixed mathematical algorithms, using defined samples and environment status, to handle concurrent applications, generally composed of: Protection, Measurement, Monitoring, Control, Event, Reporting, Recording.



Digital Protection Relays / Design Fundementals

Looking inside this digital design is the key to understanding the testing challenge. In order to interface to these devices accessability must be engineered into their physical application.



Functional Testing vs System Testing

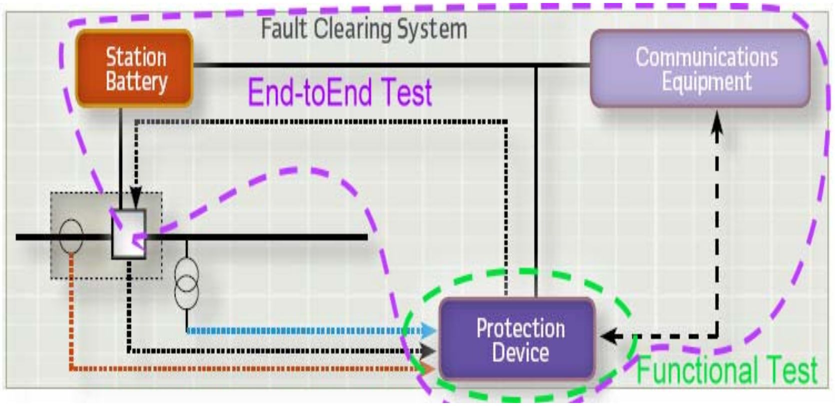
> The advantage of digital relays – they easily combine elements, status and logic for the required protection application.

> Functional testing misses the majority of what the digital relay is designed to do.

> System testing is the only logical approach.

> Digital devices perform self-diagnostics but these are not 100% inclusive of the relay design.

> The ability to test "in situ" is key to easy and efficient testing of any P&C system.



Self-diagnostics will not discover:

- a bad or failing relay output contact,
- a failed 52B contact (52A contact too),
- failing wire insulation or loose connection,
- bad turns of an interposing CT,
- inadvertent change of settings,
- an event log or report fails to generate,
- proper interlocking with another device,
- correct operation of a remote device,
- or measurement accuracies.

Engineer it to Test

Plan for testing at the *beginning* of a P&C system design

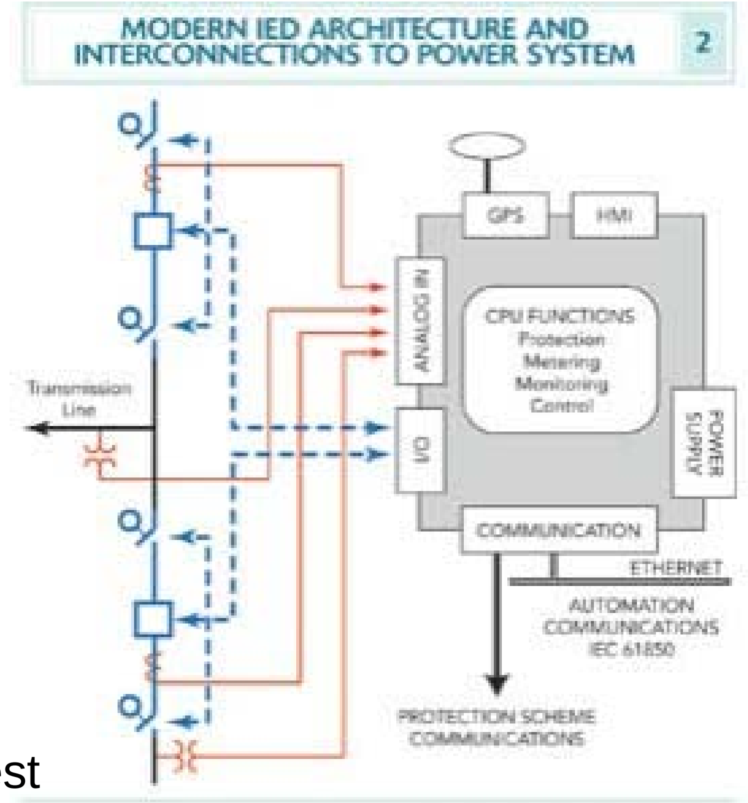
Indentify and include test interface points

Provide documentation (**FRS** – Functional Requirements Specification)

Improve P&C system drawings:
Detail all interfaces, including interlocking, communications, and distributed functions

Program the Relay to make testing easy, leverage LED's, 61850, and Monitoring

Define your test plans: Acceptance, Commissioning, and Routine testing - include benchmarks with both positive and negative test cases



"Test digital devices as they were designed – a total P&C system."

Conclusion

In summary, it cannot be stressed enough that to properly maintain a modern protection system one must begin at the planning and engineering phase in order to provide the proper design, components, programming and configuration of the protection system. Within the utility or plant all responsible parties must leverage the capabilities technology now affords to create a protection system that can be tested and maintained without conflicts. Only then will reliability and security become an automatic component of the P&C system.