

# Substation Commissioning



# Substation Commissioning

- What is substation commissioning?
  - Proving the proper operation of a newly
    - Installed
    - Replaced
    - Modified
    - Repairedpiece of equipment before it is placed into service



# Substation Commissioning

- New/replaced/repared circuit breakers
- New/replaced/repared transformers





# Substation Commissioning

- Green field substation



# Substation Commissioning

- Control Devices



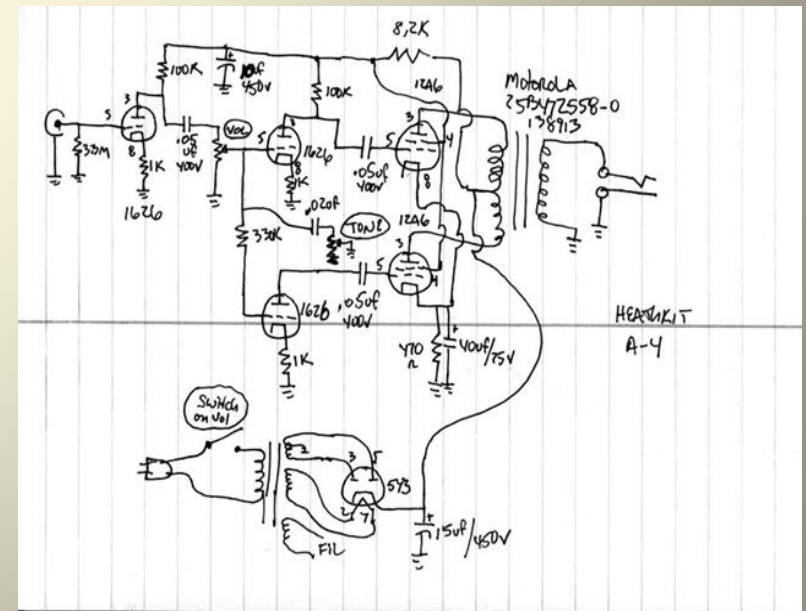
# Substation Commissioning

- New relays or modified relay settings



# Substation Commissioning

- All commissioning tasks require a good plan. In order to prove proper operation, the technician **must** understand proper operation.



# Substation Commissioning

- Safety
  - Always mitigate safety concerns
  - LOTO
  - Clearance, Hold, Tag out
  - May require help from other departments
  - When in doubt, stop





# Substation Commissioning

- Levels of commissioning
  - Simple
  - Moderate
  - Difficult



# Substation Commissioning

- Creating a game plan
  - Simple Checklist
- Cooling system contactor replacement
  - Fans/Pumps working properly?
  - All stages?
  - SCADA alarms?
  - Simple component replacement should be checked for proper operation



# Substation Commissioning

- Moderate to difficult commissioning
  - Intense familiarity with all aspects of the task at hand isn't always necessary. Sometimes there are other groups involved in the commissioning process. General familiarity with other work groups responsibilities is highly encouraged.
  - Thorough knowledge and expertise in the responsibilities of the relay technician is required.

# Substation Commissioning

- Comprehensive checklist needed for more complicated commissioning tasks

## SUBSTATION COMMISSIONING CHECKLIST

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### TRANSFORMER INFORMATION

MANUFACTURER:

SERIAL NUMBER:

MVA:

NUMBER OF WINDINGS:

SELF NUMBER:

WINDING H VOLTAGE:

WINDING X VOLTAGE:

WINDING Y VOLTAGE:

WINDING Z VOLTAGE:

LTC ? : Y N

LTC SENSING VOLTAGE LEVEL:

LTC SENSING VOLTAGE SOURCE:

COOLING SYSTEM:

COOLING SYSTEM VOLTAGE LEVEL:

COOLING SYSTEM VOLTAGE SOURCE:

COOLING SYSTEM CONFIGURATION: OA FA OAFA FOFA

NUMBER OF PRESURE RELIEF DEVICES:

STYLE OF SUDDEN PRESSURE DEVICE: RAPID RISE FAULT PRESSURE BUCHOLTZ NA

N2 SYSTEM: Y N

TYPE OF N2 REGULATION: SINGLE STAGE MULTISTAGED

MANUFACTURER RECOMMENDED N2 PRESSURE:



# Substation Commissioning

- Large component replacement
  - Transformers and Circuit Breakers
    - Acceptance tests can be performed without prints and relay settings
      - CT saturation, ratio, polarity, and insulation testing
      - VT ratio, polarity, insulation testing
      - Power Factor testing
      - Transformer turns ratio testing

Acceptance testing really only proves that the equipment was built to specifications at the factory, it survived the travel and installation, and is the baseline for future performance comparison.

# Substation Commissioning

- Testing that requires prints and settings is really the crux of the commissioning process.
- These tests include:
  - DC Circuit checks
  - AC Circuit checks
  - Relay testing
  - Trip Checks
  - Communication processor programming
  - Point to Point testing



# Substation Commissioning

- DC Checks
  - DC circuit checks can be accomplished in a few different ways, but all must be documented to stay on track.
  - A good place to start is comparing the schematics to the wiring diagrams. Mistakes can be identified and possibly rectified during construction, or upon arrival of equipment to the job site.
  - Good time to review mistakes with engineering

# Substation Commissioning

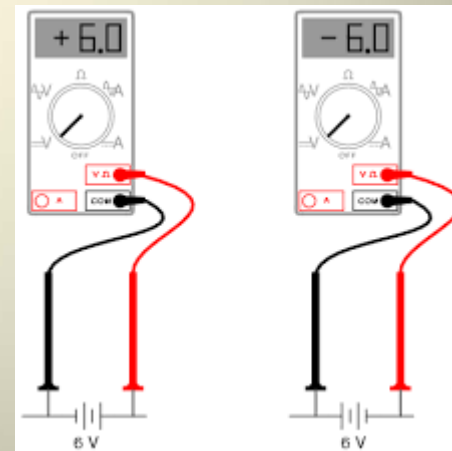
- DC Checks
  - Circuits can be “pre-tested” with continuity before DCV is applied
  - (+) DCV can be applied without (-) DCV and checks can be made
  - DCV can be applied without “pre-testing” and the location of the smoke can be noted





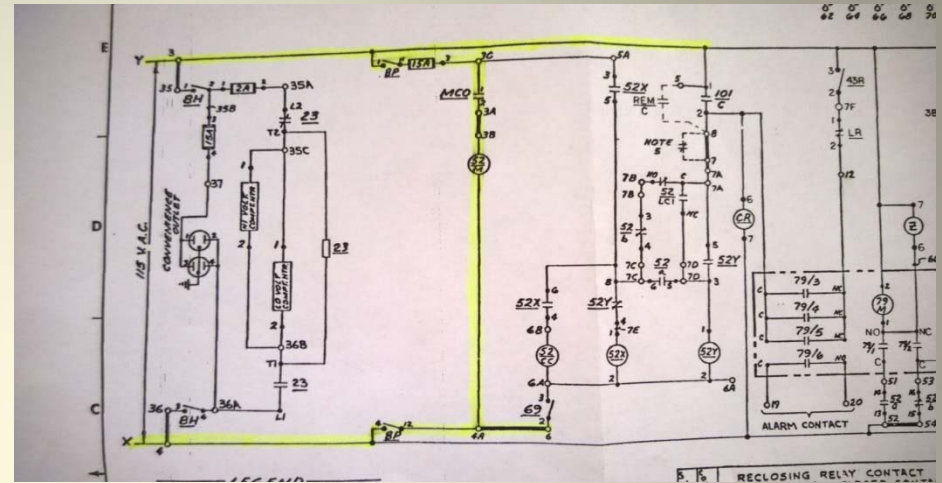
# Substation Commissioning

- DC Checks
  - Note the voltage rating of the power supply and the I/O of the relay before powering up
  - Note proper DCV polarity. Most devices are not polarity sensitive, but some are and will not work properly unless connected properly



# Substation Commissioning

- DC Checks
  - Yellow lining prints is a good way to keep track of what has checked good
  - Test switches, start with all open, then mark and close when checked good
  - Leave checked test switches closed



# Substation Commissioning

- AC Voltage Checks

- Goal of AC voltage circuit checks is to prove proper phasing and polarity throughout the circuit
- Existing phasing can be identified with equipment that has been in service
- Secondary wires checked with continuity as long as all conductors are isolated
- “Live” Bus or Line voltage can be used
- Phase between new and old secondary wires
- Metering screen on microprocessor relay

# Substation Commissioning

- AC Current Checks
  - Very important to be tested properly
  - Primary loading with prediction current flow sheet
  - Proves CT ratio, CT circuit polarity, and CT circuit continuity in one test

Substation: Talbot Hill Relay / Meter Date: 12/8/14  
 Line/XFR: 0389 Circuit test Technician: PJL

PDN <u>0389</u> BAY <u>AA</u>						Device <u>TS1 (421-4)</u>				Device				Device			
Bushing	Phase	Wire #	Wire ohms	C.T. Ratio	Pri. Amps	Sec. Amps	Phase Angle	Term. I.D.	Pos.	Sec. Amps	Phase Angle	Term. I.D.	Pos.	Sec. Amps	Phase Angle	Term. I.D.	Pos.
1	A	IRC1	.1	400-1	100	.25	2°	→E	5								
3	B	IRC2	.1	400-1	100	.25	2°	→G	7								
5	C	IRC3	.1	400-1	100	.25	2°	→I	9								

PDN <u>0389</u> BAY <u>AA</u>						Device <u>TS1 (587Z)</u>				Device				Device			
Bushing	Phase	Wire #	Wire ohms	C.T. Ratio	Pri. Amps	Sec. Amps	Phase Angle	Term. I.D.	Pos.	Sec. Amps	Phase Angle	Term. I.D.	Pos.	Sec. Amps	Phase Angle	Term. I.D.	Pos.
2	A	IBD1	.1	400-1	100	.25	178°	←E	5								
4	B	IBD2	.1	400-1	100	.25	178°	←G	7								
6	C	IBD3	.1	400-1	100	.25	178°	←I	9								

PDN						Device				Device				Device			
Bushing	Phase	Wire #	Wire ohms	C.T. Ratio	Pri. Amps	Sec. Amps	Phase Angle	Term. I.D.	Pos.	Sec. Amps	Phase Angle	Term. I.D.	Pos.	Sec. Amps	Phase Angle	Term. I.D.	Pos.

C.T. Ground: Terminal A-47 Notes: load breaker bushing 1 → bushing 2

Primary Load: 100 amps



# Substation Commissioning

- AC Current Checks
  - Secondary injection also viable test.
    - Only way to test transformer CT circuits
    - Extreme care must be taken to get polarity correct
    - Documented same as Primary load test
    - Predicted results



# Substation Commissioning

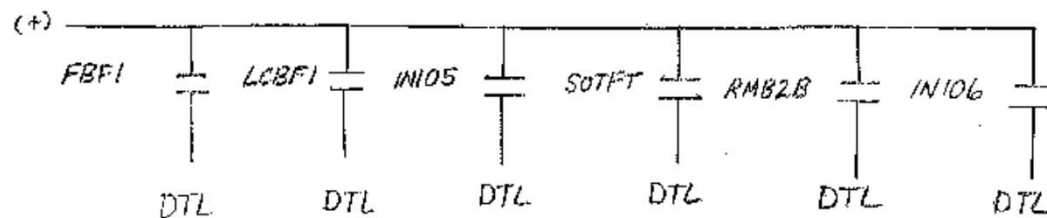
- Relay Testing
  - Testing the relay is managed in different ways, but the goal is to prove the relay settings, relay logic, and relay functions are all working to “as set” settings
  - Element testing can be accomplished via manual or automatic testing
  - Strive to test relay logic with real dynamic testing

# Substation Commissioning

- Dynamic Logic Testing
  - Don't just pulse/jumper contacts, create relay reaction by injecting values into the relay
  - Use logic diagrams and yellow line them as they are tested is a great way to understand the relay logic
  - Better yet, draw your own logic diagrams and test them

# Substation Commissioning

*Recloser Drive to Lockout Logic :*



*FBF1 = Fault Level Breaker fail*

*LCBF1 = Load Current Breaker fail*

*IN105 = c/o switch turned off*

*SOTFT = Switch On to Fault Logic has asserted*

*RMB2B = Receive Reclose Cancel from Relay 2*

*IN106 = RAS trip received*

# Substation Commissioning

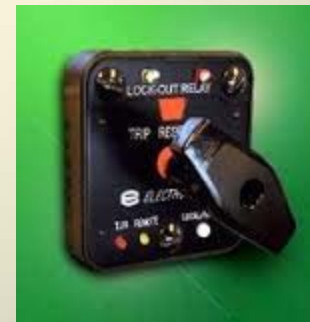
- Dynamic Logic Testing
  - Make breaker reclose or not reclose
  - Block close by injecting false sync values
  - Block transfer tripping with c/o switch
  - Roll LOR with Breaker Failure or DTT RX





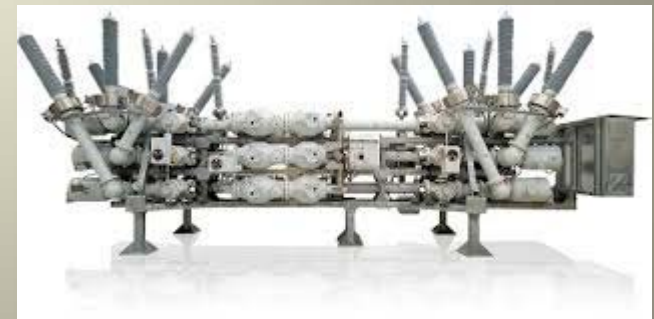
# Substation Commissioning

- Trip Checks
  - Vital to proving proper operation of all devices
  - Electrical and mechanical



# Substation Commissioning

- Circuit Breakers
  - Trip from all known tripping sources
  - Trip from mechanical devices such as low gas
  - Test each trip coil individually
  - Trip breaker failure back up devices
  - Trip to/from remote sources if using Transfer Trip



# Substation Commissioning

- Transformers
  - Trip from all known tripping sources
  - Trip from mechanical devices such as low oil and sudden pressure
  - Trip from cooling related issues
  - Trip breaker failure back up schemes
  - Trip and lock out



# Substation Commissioning

- Communication Processor Programming
- Meter testing
- TOP-006 testing
- Communication circuit testing
- End to end testing
- Pre check alarm circuits





# Substation Commissioning

- Point to Point
  - Complete final check of proper operation of all new devices in the substation
  - Control points
  - Analog points
  - Alarm points
  - Verified to remote control center





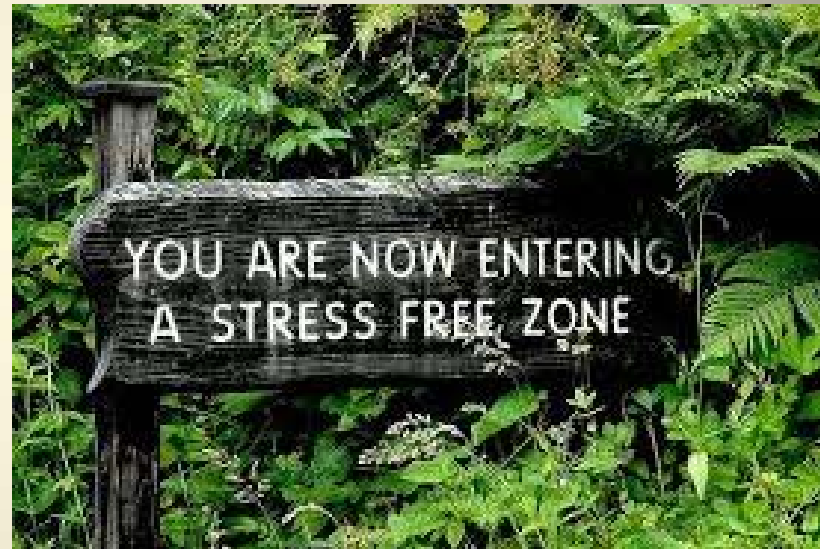
# Substation Commissioning

- Energization Day
  - Expectations
    - Could be a long day
    - Problems may arise
    - Plan to mitigate problems
    - Personal safety
    - Non field personnel in substation
    - Confident
    - All protective devices in service



# Substation Commissioning

- Post Energization
  - Setting files
  - Red/Green prints
  - Complete all documentation
  - “Honey do” list
  - Best commissioning jobs are the substations you never hear from



# Substation Commissioning

- Conclusions
  - A well thought out plan will guarantee the best chance for a successful commissioning job regardless of size of scope
  - Strive for a plan that will “double check” yourself
  - Ask for help when it’s needed
  - Have confidence in your approach

# Thank You

