Distribution Substation Commissioning

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Distribution Station Differences

• Transformer connections
  – Voltage regulation
  – Protection methods

• Breaker arrangements
  – Metal enclosed
  – GIS

• Power cables

• Arc Flash exposure enhanced

• Other control schemes
Transformers

- Delta Wye most typical
  - Single or 3 phase
- Delta – Delta – legacy or special application
  - Grounding Banks – Wye Delta or Zigzag
  - Industrial feeds
    - May see dual low sides Delta-Wye, Delta-Delt
- High impedance grounding
Voltage regulation

• Bus voltage regulation –
  – Automatic controlled Tapchangers
  – Automatic controlled Regulators
    • Single phase or 3 phase
  – Capacitor Banks

• Contact Integrity Test of LTC or Regulator
  – Winding resistance test set or
  – Micro-ohm meter.
Dynamic Resistance of LTC
Dynamic Resistance of Regulator

Figure 5.0 Typical LTCA-40 Connection Diagram (Dynamic Resistance Test)
Transformer Protection

• Fuses
• Circuit Switchers
• Transrupters
• Circuit Breakers
Fuses

• One shot device
• New from the box
  – How long has it been in storage
  – Storage environment
  – Still sealed in plastic?
• QA on manufacturer
  – Infrared
  – Micro-ohm
Circuit Switchers

• Micro-ohm contacts
• Functional test
  – Device timing
Transformer Relaying

- Overcurrents –
- Differential
- REF ground
- In-service vs. Off Line functional
- Safety when Energizing
Transformer Short Circuit testing

- Create circulating current in transformer winding.
- Measure secondary CT currents.
- Verify magnitudes and phasor relationships.
- Can check any other transformer internal CT’s
Diagram of short circuit test HV

Electrical Setup for
Differential Relay
Neutral CT Connection
Verification Test

Dgn: R. Asche
11/22/10

NOTES:
1. If the Transformer Main low side breaker is not installed look for the set of CTs on the entrance to the switchyard.
2. Single-phase Step-up transformer has a 2.4 kV / 7.2 kV selector. Leave on 2.4 kV.
Diagram of short circuit test LV

Electrical Setup for
Differential Relay
Neutral CT Connection
Verification Test

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NOTES:
1. If the Transformer Main low side breaker is not installed look for the set of CT's on the entrance to the metered load.
2. Current Amplifier is 5A to 40A CT. It is optional, but desirable to boost current levels.
REF GROUND

• Highly sensitive for internal ground faults
• Calculated Zero Sequence currents
• Measured Ground current
• “Ground” differential
• Included in previous test. Verify polarity of Neutral CT connection.
Transformer LDC

- CT polarity must match PT polarity.
Switchgear

• Open Air – Free Standing – Oil, Vacuum, SF6
  – Self contained – includes relays
  – Breaker only

• Metal-Enclosed
  – Vacuum, Air, SF6
  – GIS
CT’s in Metalcad

- Mounted in cubicle behind shutters
- Not visible
- “primary removed” when breaker racked out
- Need to remove breaker from cubicle
- Bus must be dead!
- Short main bus – phase to phase
- Short feeder terminals – phase to phase
- Connect to tulips from front side
CT ratio checking method 1
CT Ratio Test method 2
PT tests in Metal clad

• Check ratio and polarity in racked out pos.
• Apply test voltage to PT primary and follow through all devices one phase at a time.
Bus Differential Testing

• Arc Flash protection is requiring faster bus protection
• Distribution buses now getting Bus differential schemes
• Old practice to block diff – energize – test – enable.
• New practice – diff always enabled when energizing
• Test off line
Bus Differential Testing

- Is Transformer Contribution from CT’s on Transformer?
- Is there a main breaker?
- Is protection summed or individual?
DISTRIBUTION BUS DIFFERENTIAL COMMISSIONING
STEP 1

Electrical Setup for
Bus Differential CT Connection
Verification Test

WR-x
12.26Mva
120/13.2
8.0% - 7.5 ohms
Sec Z1

87B
SEL 487B
SEL 567Z
IAC
ABB

2000/5 typ
X0
X1
X2
X3

Variac or Test Set
Current Amplifier
Reference

Move to each Phase and Each Breaker Position
DISTRIBUTION BUS DIFFERENTIAL COMMISSIONING
STEP 4

Electrical Setup for Bus Differential CT Connection Verification Test

WR-x
10/28 MVA
120/13.2
6.0% - 7.5 ohms
Sec Z1

SEL 497B
SEL 9372
IAC
ABB

87B

Connect between breaker pairs – 1 phase at a time.
Can keep common reference point for all tests.
Hi-Pot Testing

• AC preferred - 2E+1k new
• Circuit Breakers
  – Vacuum bottle
• Enclosed buswork
Cable Testing

- New Cable – VLF or DC
- Service Aged Cable – VLF (.1 Hz)
Control Schemes

• Line Sectionalizing – Transfer Schemes
• Breaker – Reclosing, Hot Line Tagging, Inst blocking, cold load blocking
• Under Frequency
• Under Voltage
Transmission Line Transfer
Arc Flash Testing

• When testing an Arc Flash scheme – you Don’t have Arc Flash Protection
• Optical Flash Relay
• Optical Flash with Fault Current Supervision
• Instantaneous Overcurrent Relay
• Bus Differential Relay
Getting Away from it...

- Longer test leads
- Long serial cables or wireless port
- Operate via SCADA
- Chicken Switch  
  – Commercial or home made
- Book a trip to Bora – Bora