Case Study: High-Density Distribution Coordination Using High-Speed Communications

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## What is an HDC scheme?

| Overcurrent coordination of many devices with fast operating times | Peer-to-peer communications scheme (vs. centralized) | Blocking signal that is sent over Ethernet fiber when fault current is seen (IEC 61850) |
What is an HDC scheme?

| Allows device to trip fast – unless it receives two blocking signals | Uses existing time-overcurrent coordination if two blocks are received | Clears fault within 7 cycles, regardless of location or magnitude limitations |
Why is an HDC scheme needed?

Increasing recloser installations allows for ~400 utility customers in each line section, improving SAIDI and SAIFI.

This increase results in significantly more devices that need to coordinate to maintain selectivity.

Maintaining standard coordination margins can therefore be difficult or impossible.
Traditional coordination

- All relays must coordinate to maintain selectivity
- Upstream fault time may be measured in seconds
- Some margins might not coordinate to keep trip times down
HDC principles

All devices publish block signal when current is over minimum phase trip level

Device trips fast after short communications time delay if less than two block signals are received
HDC principles

Always-functional fast and delay curves
If communications fail, all faults cleared with standard coordination

Minimum trip pickup
Set below most sensitive high-current trip

Comm-supervised fast trip
3-cycle delay (provides time for block receipt)
Coordination with noncommunicating laterals (fuses)
Traditional coordination vs. HDC scheme

All HDC reclosers set to same curve

3-cycle communication and coordination delay
Relay logic – send block
HDC scheme implementation

- 3-phase element block
- A-phase element block
- B-phase element block
- C-phase element block
- PB05: Initiate test pushbutton
- TMB1A: Blocking bit
- TMB3A: Test bit
- TRIP3P, TRIPA, TRIPB, TRIPC, 3PO: Device looks closed (based on current flow)
- VarTmr: Breaker failure timer
- Latch: Breaker failure latch
- SV52: Target reset pushbutton
- LT25

Breaker failure
Relay logic – block received
HDC scheme implementation

MV06
High-current trip-phase active shot number

79SHA
A-phase shot counter

SV02
Reclosing defeated

SPE
Single-phase operation enabled

LE
Which shot HD block asserts for

MV06

0

GE
Block signal enabled

RMB2A
High-density block

RMB1A
HD network healthy

ROKA
Communications to controller healthy

HBL2AT
Harmonic inrush A-phase blocking

50A2TC
High-current trip-A (HD scheme block)
Edge devices

- Reclosers at network boundaries can receive only one block
- Second block signal is provided by edge logic
- Faults outside network are time-delay cleared
Example system

Outside of network – traditional coordination

Substation bus
Transfer bus
B1 B2
1st down-line device
NO
Not in HDC scheme
R1 R8
R2 R9
R3 R4 R10
R11
R12
R7
R6
R5

Normally open

Edge devices

Not in HDC scheme
Fault near substation

- Fault occurs before first down-line recloser
- Only B1 detects fault and transmits block
- B1 trips on fast curve after requisite 3-cycle delay
Fault near substation

- Fault occurs past first down-line recloser
- B1 and R1 detect fault and transmit block
- R1 trips on fast curve after requisite 3-cycle delay
External fault

- Edge device R11 gets second block from internal logic
- R12 clears fault with traditional time-overcurrent delay
- If R12 fails, original coordination takes over and R11 clears fault
External fault

R11 clears fault with traditional time-overcurrent delay
Back-feed fault

- R11 receives first block from communications network (from R10)
- R11 trips if fault is between R10 and R11
Alternate feeder fault

- Feeder breakers must subscribe to all first down-line reclosers, but those reclosers subscribe only to original feeder breaker
- GOOSE subscriptions are programmatically limited by design to 15 devices
- All feeder topologies in scheme can have no more than 15 electrically adjacent devices
- This limits feeders exiting substation to 15 feeders total
Transferred feeder fault

- First recloser outside substation fence on faulted feeder does not get a block from B1
- R8 trips – not desirable but acceptable
- Transferred feeders are temporary conditions
Looped feeder fault

- Scheme foregoes coordination during short time system is tied together
- Fault is cleared with traditional time-delay overcurrent protection
- Most likely fault location is recently closed switch
Trip failure fault

- Breaker failure logic stops block signal
- Next upstream device trips when block signal stops
Communications failure fault

Electrically adjacent devices revert to fast and slow curve time-delay coordination.
Communications test

Test mode for block publication and subscriptions
Feeder outage after HDC

9/25/18

Duration = 402 minutes
Affected = 2 customers
Total CMI = 804
RD0556 A-phase overcurrent
RD0556 B-phase overcurrent
RD0556 C-phase overcurrent
RD0556 breaker status
RD0556 block received
RD0556 block transmitted

RD0576 A-phase overcurrent
RD0576 B-phase overcurrent
RD0576 C-phase overcurrent
RD0576 breaker status
RD0576 no block received
RD0576 block transmitted

Current (A)
8,000 – 8,000
8,000 – 8,000

Voltage (kV)
10 – 10
10 – 10

108.367 ms

HDC operation
9/25/18
Summary

Is simple in principle

Is adaptable to most feeder configurations or reconfigurations
  - No settings changes required
  - No modifications to communications required

Has inherent directionality
  - Using fault current detection
  - Using blocking signals
Summary

High-speed protection extends to end of feeder regardless of fault current magnitude

Scheme is generally agnostic to the recloser

Phase 2 of project adds miscoordination logic to mitigate loop conditions and other atypical configurations
Questions?