AMERICAN ELECTRIC POWER
BOUNDLESS ENERGY™

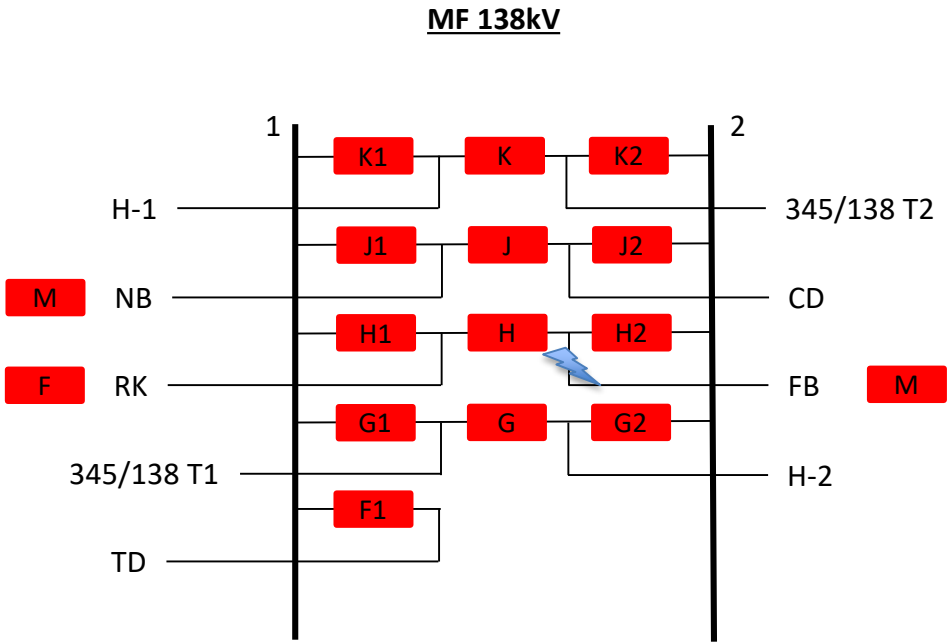
AEP Misop Event February 23, 2019

Presented by: Phillip Lux

74th Annual Conference for Protective Relay Engineers
Texas A&M University
March 22 - March 25, 2021

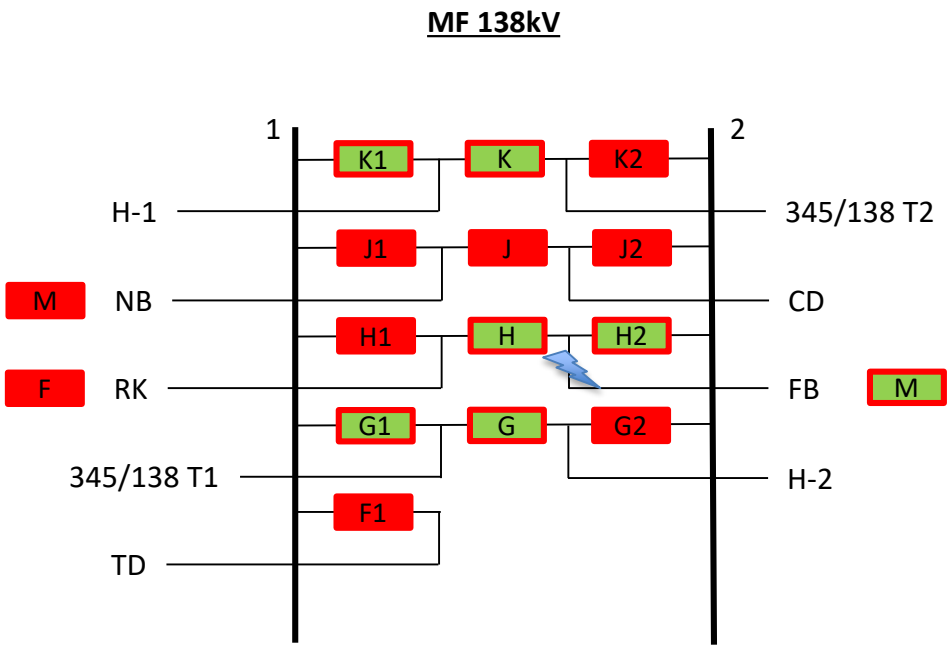
- 138kV Line exit arrester failure event
- Five of Seven 138kV lines outaged
- Two 345-138kV Autos outaged
- One of Two 138kV Buses outaged
- Five Protection Misoperations Occurred

Pre-fault Configuration



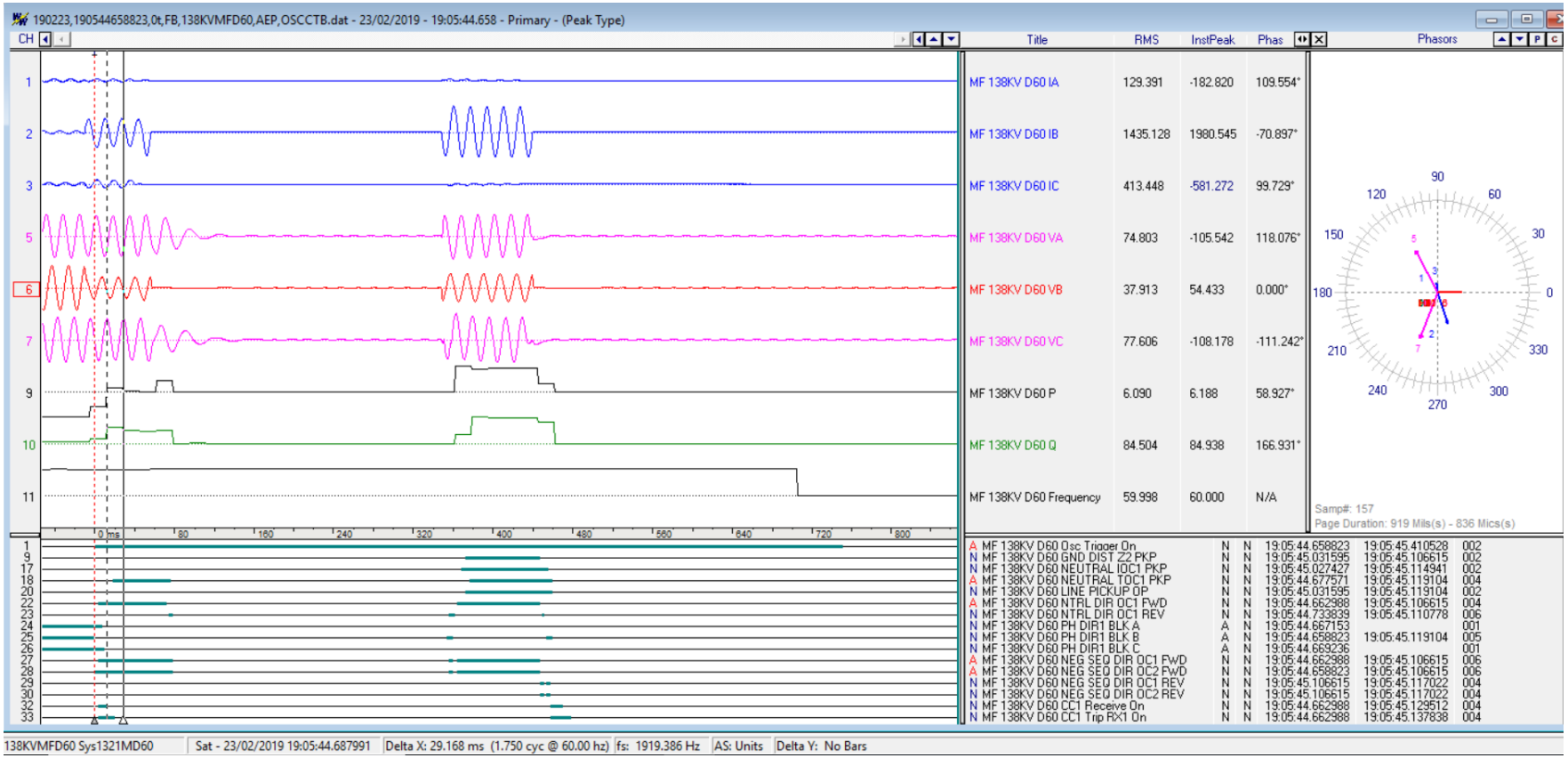
- 138kV MF Station
- System Normal
- BG fault at 14:05:44
- Location unknown
- Suspect start of arrester failing

1st Fault Operations (14:05:44)

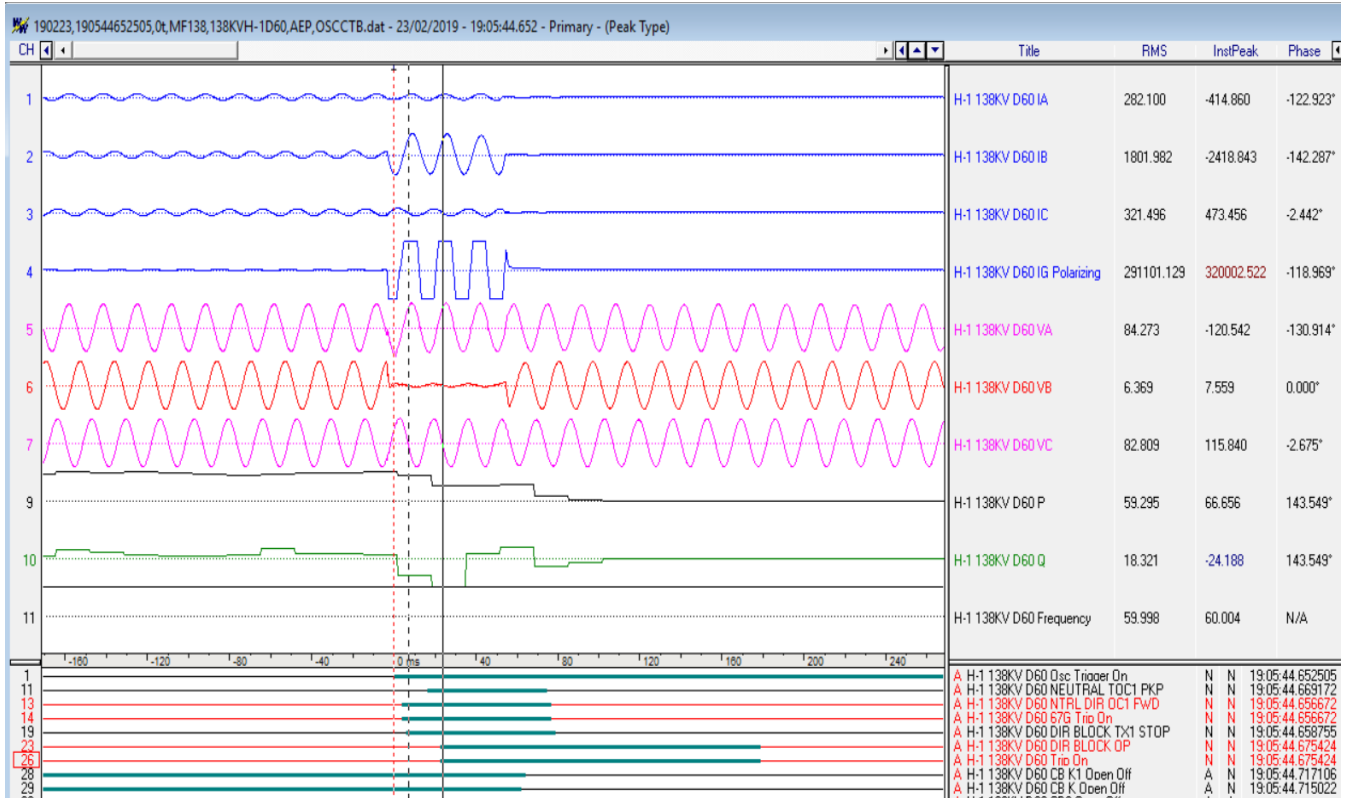


- FB-MF line operates.
  - MF end relays tripped on Neutral IOC. Records from these line relays were unavailable. (Proper Operation)
  - FB end relays operate on DCB scheme (trip/close/trip). (Proper Operation)
- Polarizing current reference at MF is unreliable, induced currents in polarizing string.
- H-1 line D60 relay trips via DCB scheme at MF end. (Misop)
  - Current Polarizing causes neutral directional element to falsely indicate forward direction.
- T1 CBs G1 and G trip. (Misop?)
  - No protective relay operations, only trip coils.
  - We believe induced voltage activated the 345 to 138 house tripping equipment for control switch trips.
  - No PRC-004 Misop.

1st Fault and Reclose (FB end)



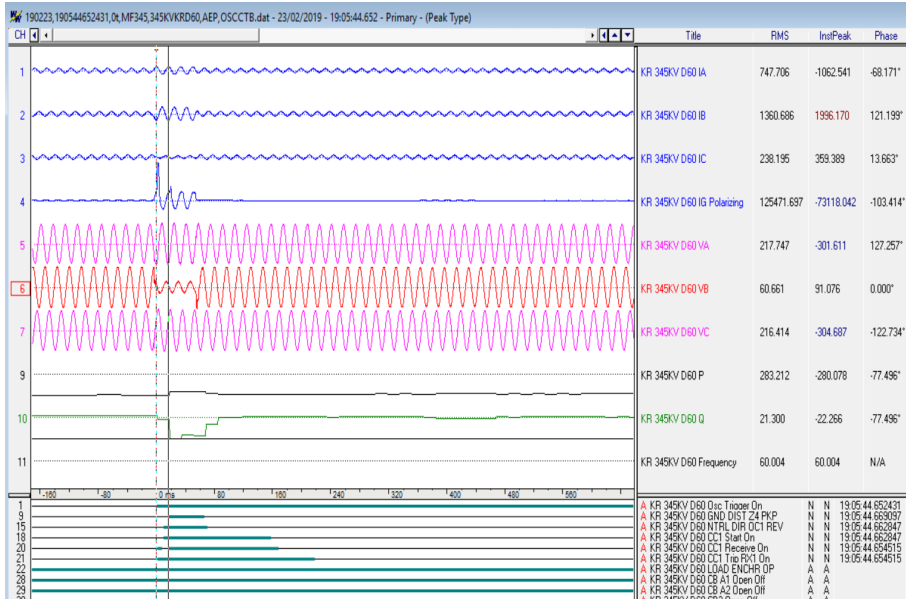
1st Fault H-1 Misop (MF end)



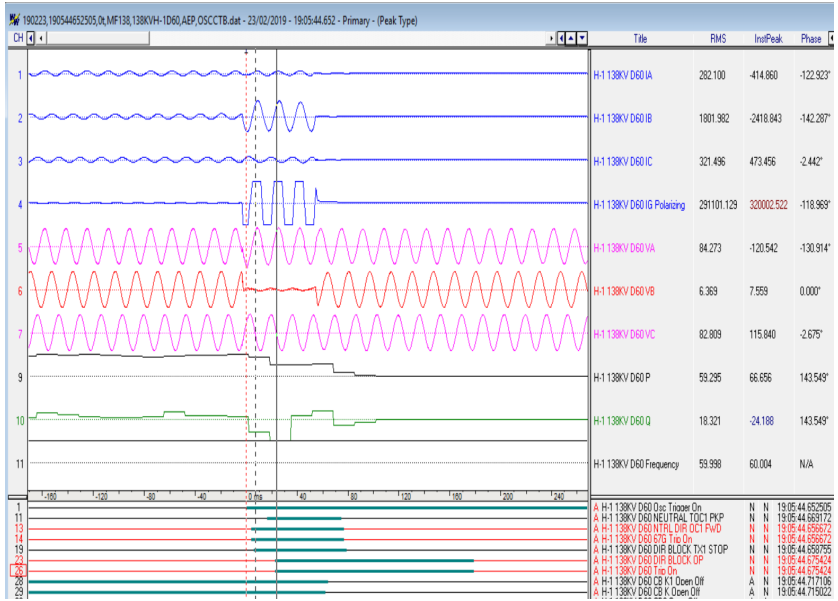
- Reverse BG fault
- IPOL is clipped and in-phase, thus forward declaration and DCB trip (Misop)
- Caused by induced currents in IPOL

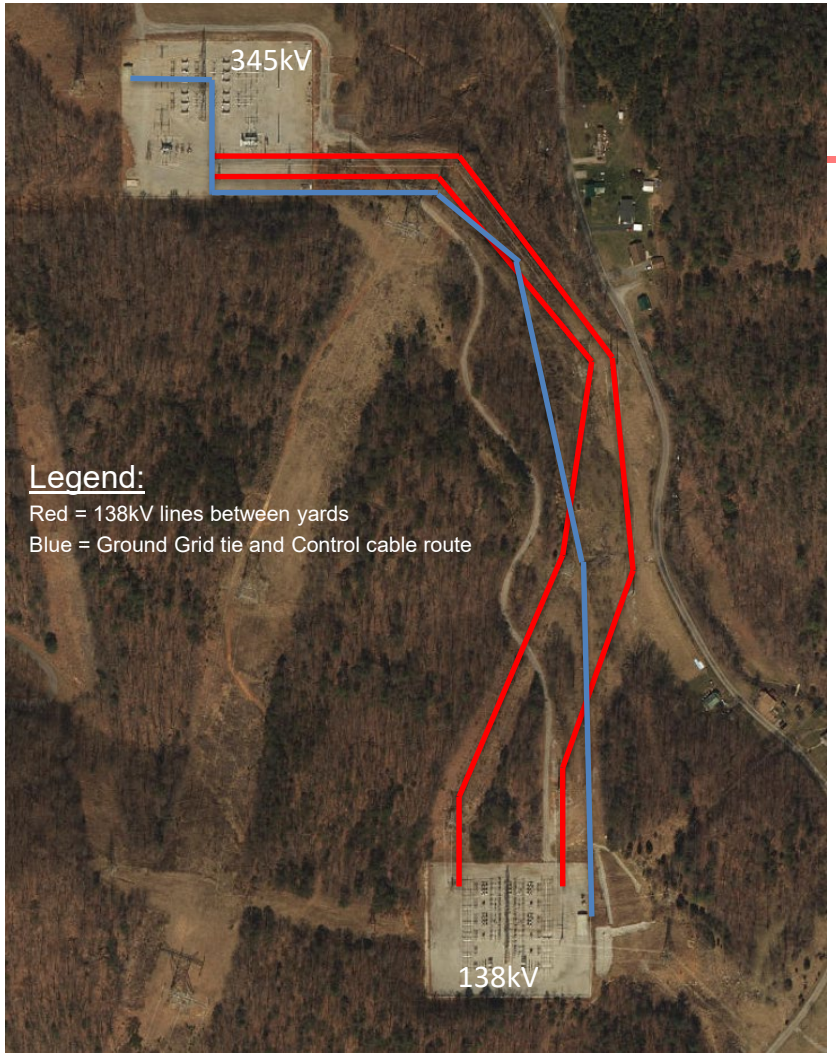
1st Fault MF Polarizing Comparison

MF 345kV Yard:



MF 138kV Yard:

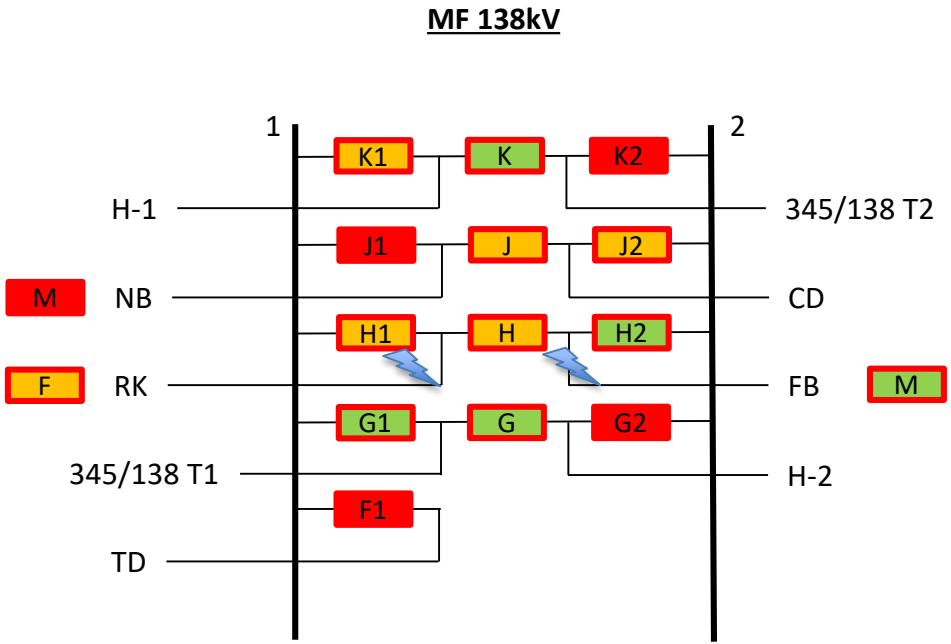




MF Station Layout

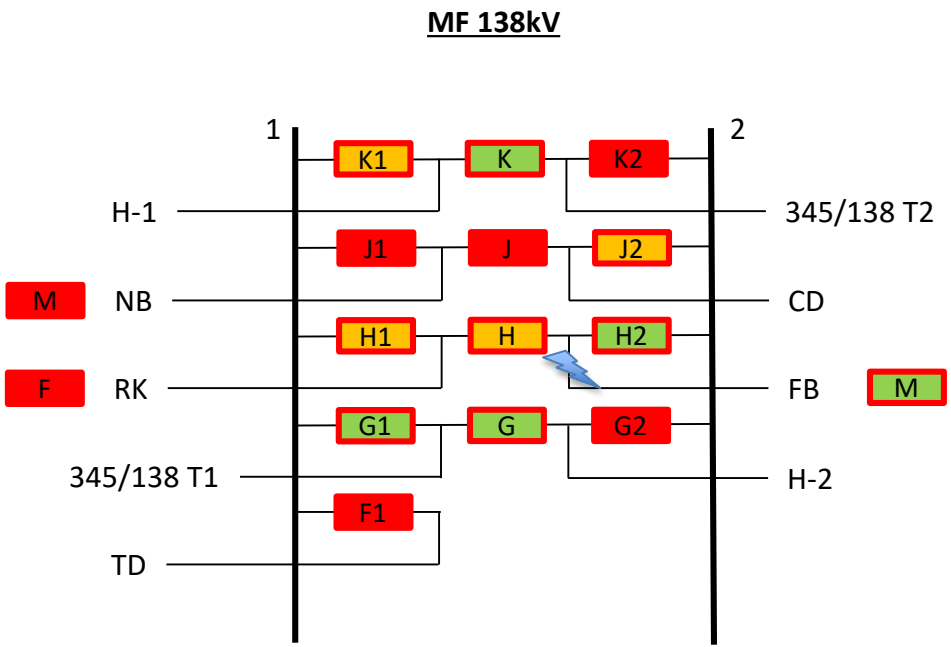
- House to House control cable is approximately 0.6 miles in length.
- Ground Grids are separated by 0.32 miles at the closest point.

Reclose & 2nd Fault Operations (14:05:54)



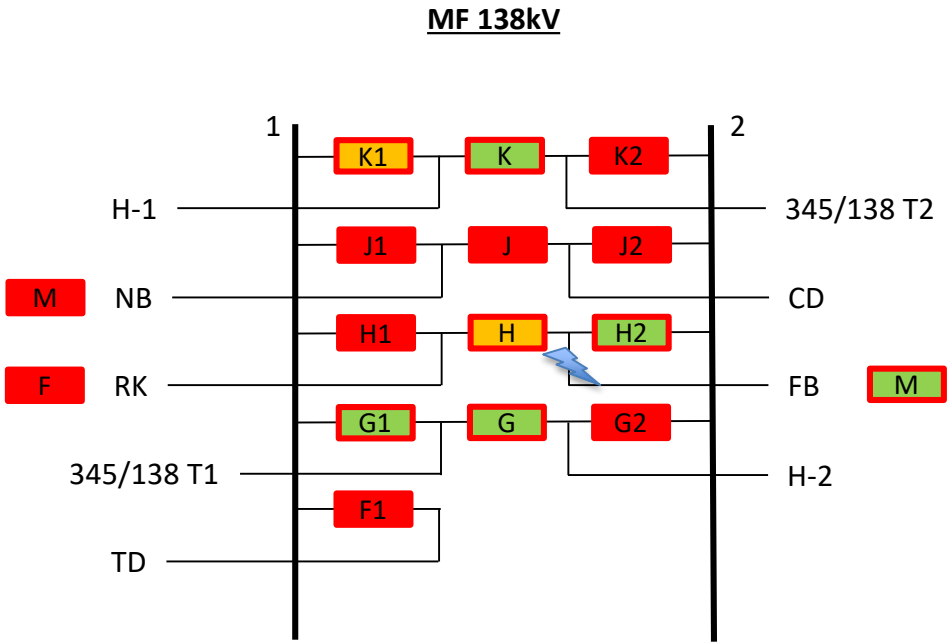
- CB H and K1 reclose after 10 seconds
- Permanent BG fault – failed arrester
- CB H trips again (Proper)
- MF-RK line trips (Proper)
  - Records indicate there was a concurrent fault on this circuit
  - RK and FB circuits exit station on the same structure (top/bottom config.)
- H-1 line trips again at MF end. (Misop)
  - Same issue as before with polarizing current.
- CD line trips at MF end (Misop)
  - Current polarizing causes neutral directional element to mistakenly indicate a forward fault.
  - Relays operate on Neutral IOC.

Reclose & 3rd Fault Operations (14:06:00)



- CB F at RK end recloses after 17 cycles
- CB J recloses
- CB M at FB end recloses and trips (Proper), then line sectionalizes at tap station and M recloses

Reclose & 4th Fault Operations (14:06:19)



- CB H2 recloses and trips (Proper)

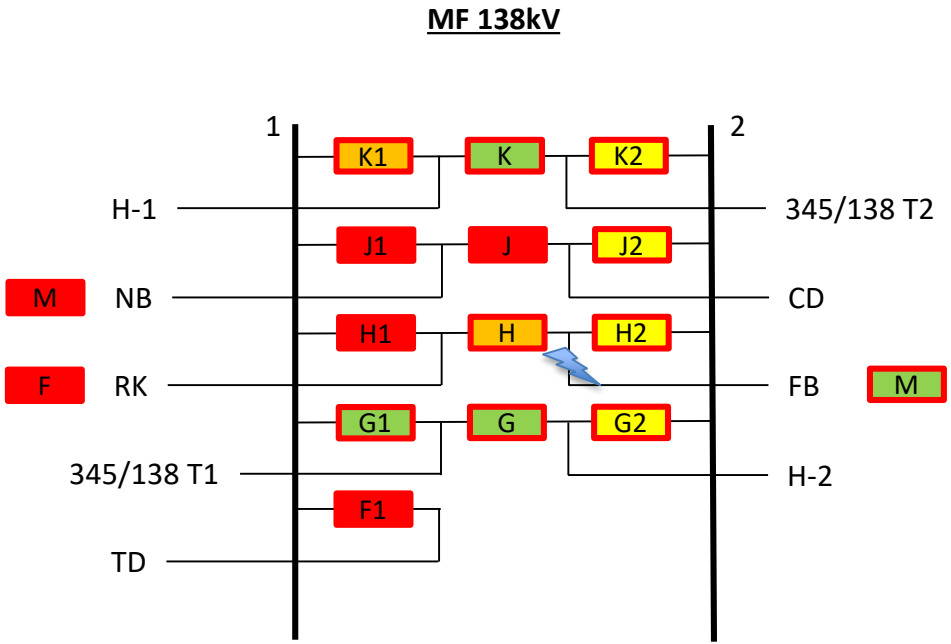
14:06:24:

- CB J2 recloses

14:06:39:

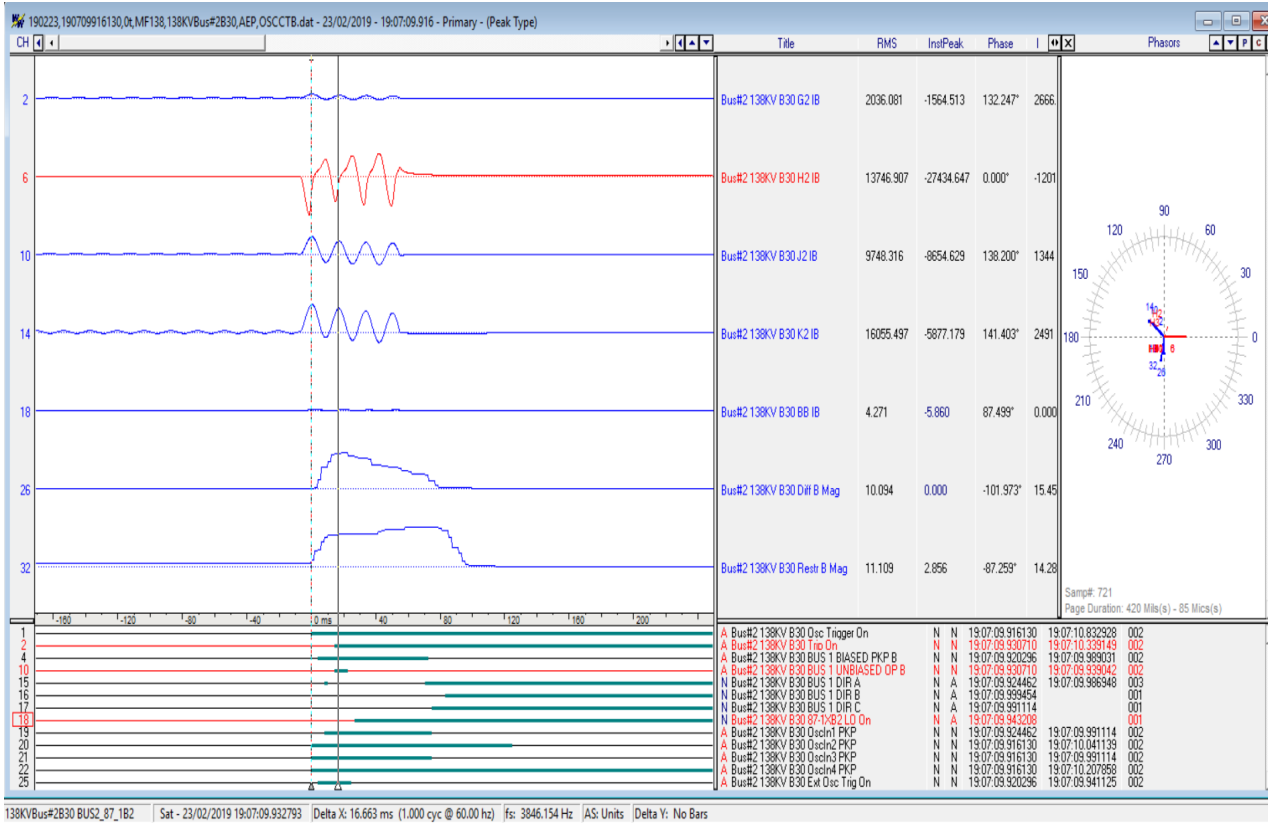
- CB H1 recloses

Reclose & 5th Fault Operations (14:07:09)



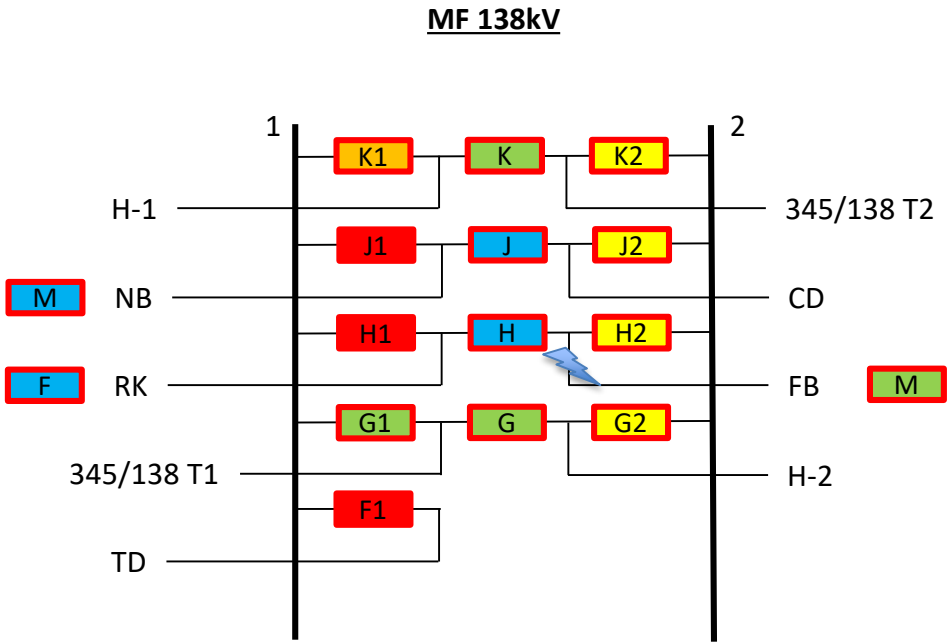
- CB H2 recloses with 25kA on B phase
- CB H2 CT saturates, only measures 15kA
- Bus 2 B30 differential relay measures operate current exceeding unbiased trip level (10kA)
- Bus 2 B30 trips by Unbiased Differential Trip Element (Misop)

5th Fault and MF Bus 2 trip (B30 relay)



- Bus 2 B30 trips by Unbiased Differential Trip Element (Misop)
- Unbiased Element is NOT supposed to be enabled for tripping

Reclose & 6th Fault Operations (14:08:10)



- CB H recloses and trips again to lockout (Proper)
- RK end CB F trips (Misop)
  - Trips by Neutral IOC
  - Current scenario is ~N-4
  - Neutral IOC set for only N-1
- CB J trips again (Misop)
  - Same issue as before with polarizing current.
- NB end CB M trips (Misop)
  - Trips by Neutral IOC
  - Current scenario is ~N-4
  - Neutral IOC set for only N-1
- Finally, no further operations.

Corrective Actions Taken

- MF-H1 138kV line Misop
  - Removed Current Polarizing circuit
  - Changed polarizing to Negative Sequence
- CD-MF 138kV line Misop
  - Removed Current Polarizing circuit
  - Changed polarizing to Negative Sequence
- MF 138kV Bus 2 Misop
  - Unbiased 87 element trip disabled
  - CT ratios increased where possible
- MF-RK 138kV line Misop
  - Increased Neutral IOC setting at RK end
- MF-NB 138kV line Misop
  - No CAP Declaration made due to inability to improve Neutral IOC setting (multiple contingency condition)
- 345-138kV Auto CB trips at 138kV end
  - Removed hardwire control switch trip circuits between the two yards
  - Installed (4) SEL-2506 relays (one pair for each Auto) for control switch trips.

Questions?