

# **The Language of “Squiggly Lines”**

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# My Job?

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**“I look at squiggly lines all day long.”**

**Ryan Knapp - AEP**

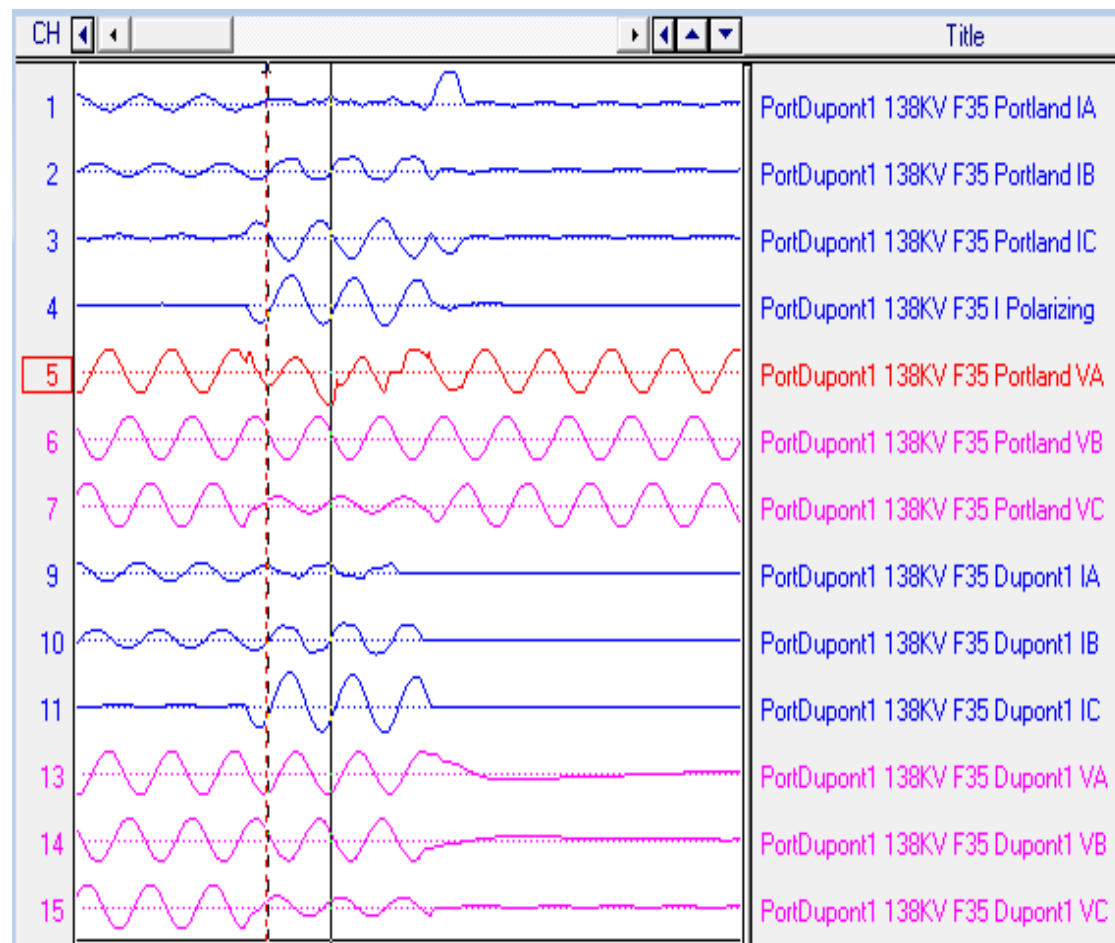
# Misoperation Topics

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- ❖ **Strange Voltage Waveforms 1**
- ❖ **Strange Voltage Waveforms 2**
- ❖ **Last CB to Clear the Remote Bus Fault**
- ❖ **Transformer Differential Winding Compensation**
- ❖ **Phase Labelling**
- ❖ **Mother Nature's Critters**

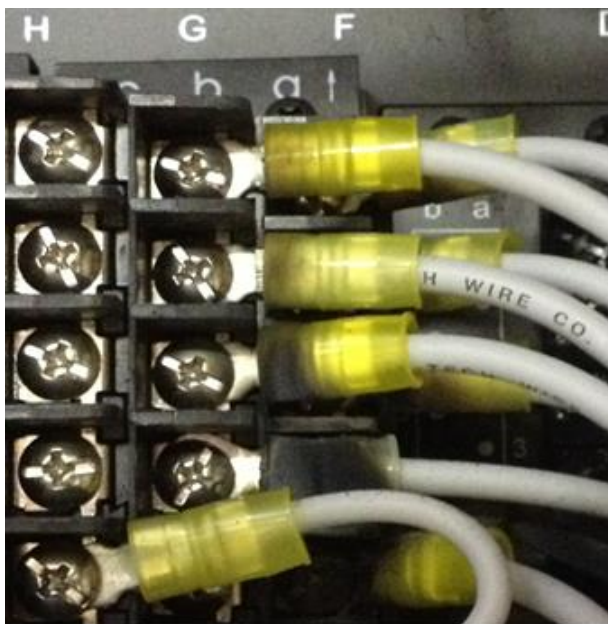
# Strange Voltage Waveforms 1

- ❖ POTT 67N misoperation caused one end of line to trip during out of zone LG fault.
- ❖ Non-tripping end declared reverse LG fault forward in error at the start of the fault for a very short instance (negative sequence polarizing).
- ❖ Why is the unfaulted VA channel 5 distorted as compared to VA channel 13?



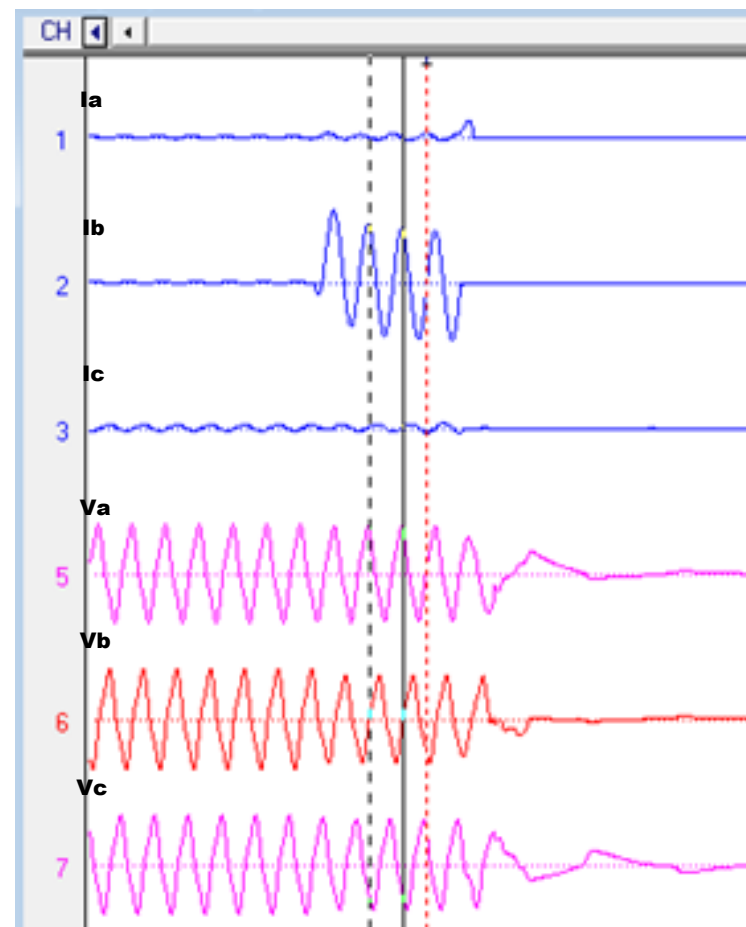
# Strange Voltage Waveforms 1

- ❖ Found DME device with flashover marks between VA (F5a) and IPOL (F4a) terminals to be the cause of the distorted VA signal to the F35 and the two POTT relays. Wrong wire lugs were used.
- ❖ This could only be seen during LG fault conditions.



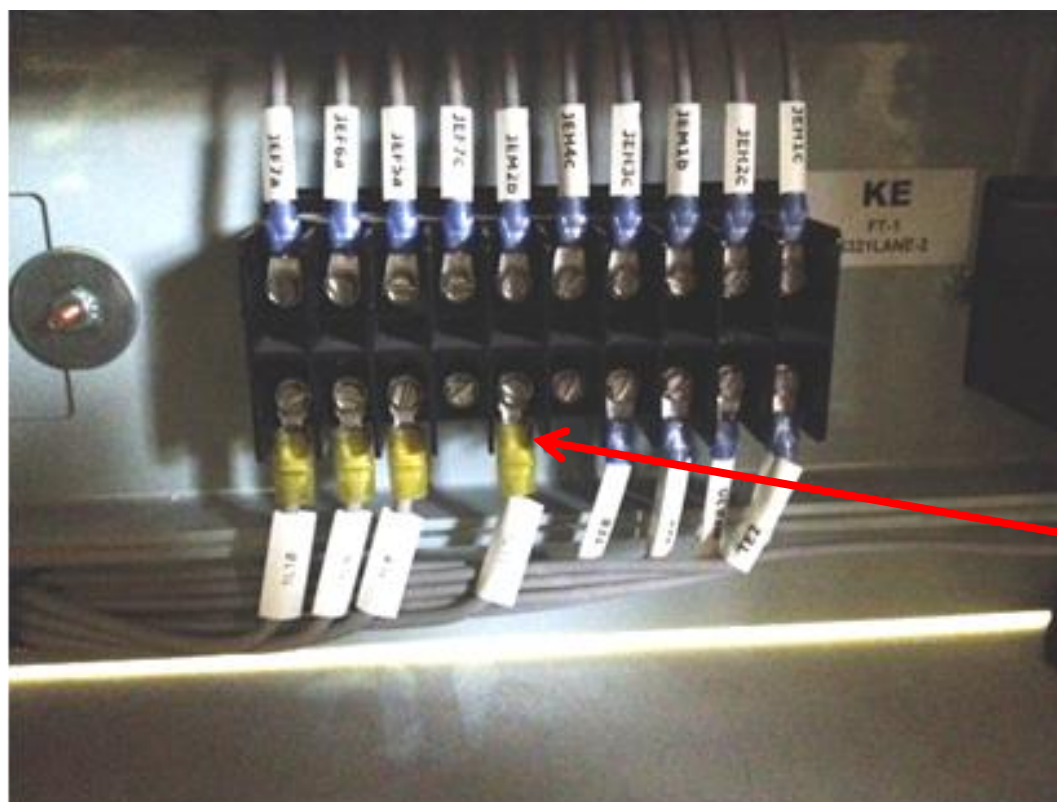
# Strange Voltage Waveforms 2

- ❖ Primary DCB relay declares reverse LG fault as forward and allows misoperation of line at both ends by DCB 67N.
- ❖ Why are the voltage waveforms triangular in shape and not smooth sine waves?
- ❖ Backup relay showed proper voltage waveforms.
- ❖ Calculation of  $3V_0$  revealed  $3V_0$  magnitudes of 40% nominal during pre-fault causing directional error to be made during LG fault.



# Strange Voltage Waveforms 2

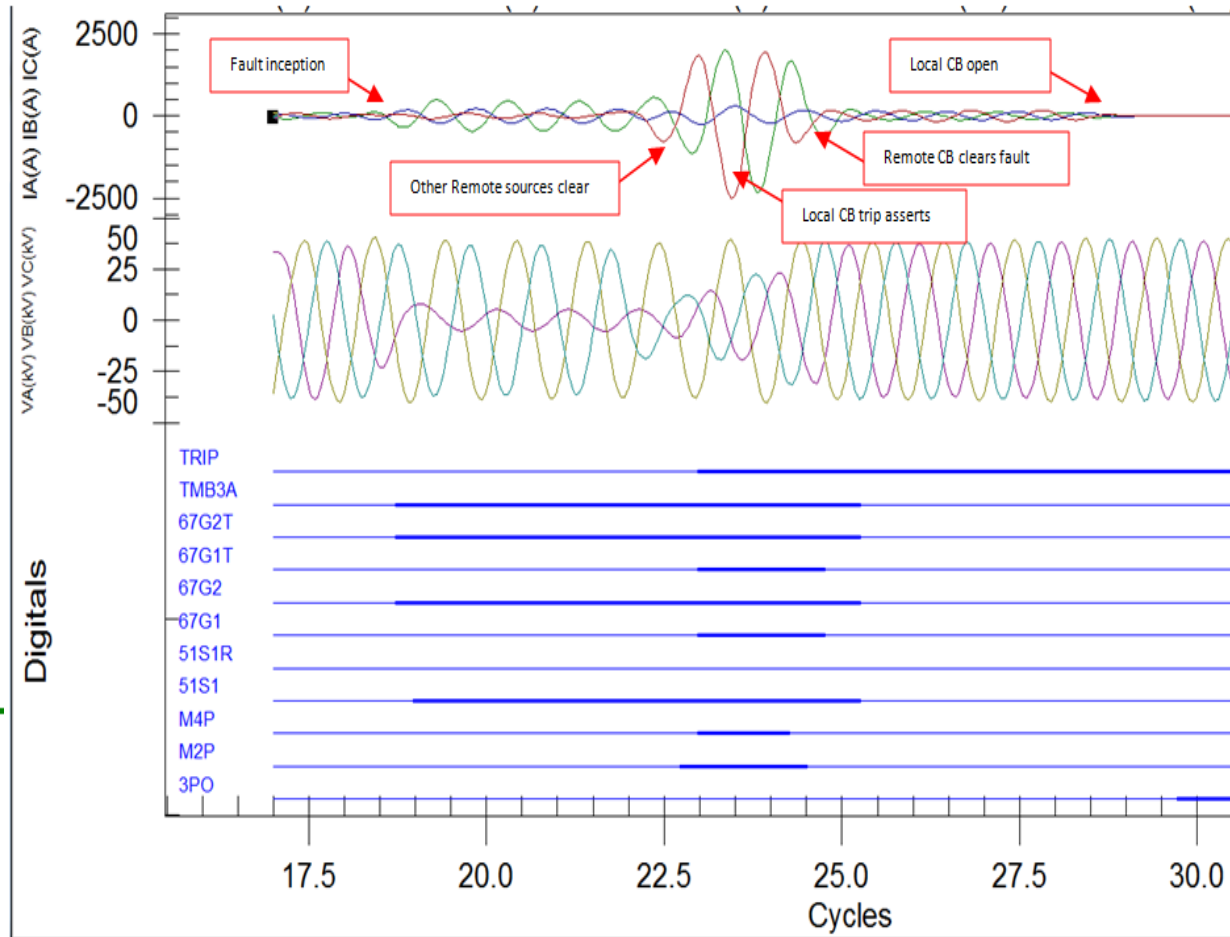
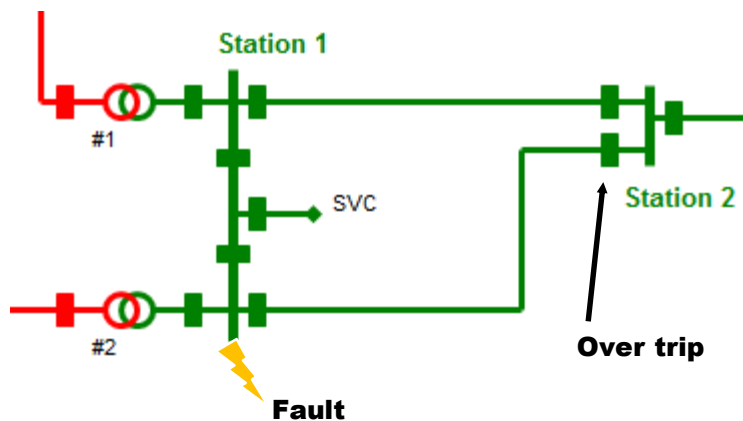
- ❖ Cause due to Relay VN not connected to VN of CCVTs (wiring error).
- ❖ Obvious issue when viewing high sample rate oscillography.



**VN on wrong terminal**

# Last CB to Clear the Remote Bus Fault

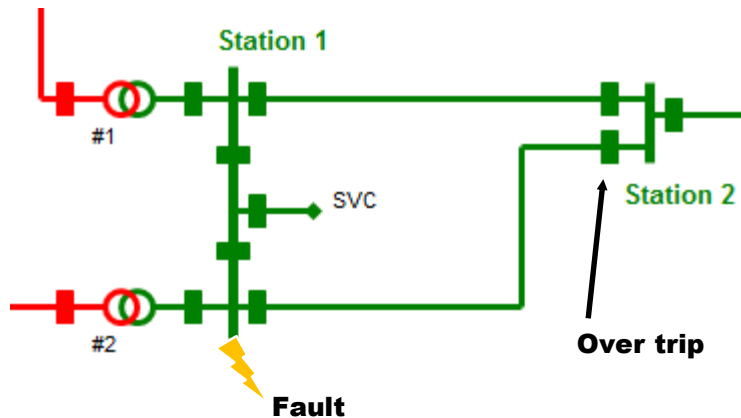
- ❖ Station 1 LG Bus fault with Station 2 67N INST over trip.
- ❖ Last CB to clear the bus fault is the line CB. Station 1 CBs clear the fault properly with the last CB clearing in 6.5 cycles, which is proper for an old Oil CB.





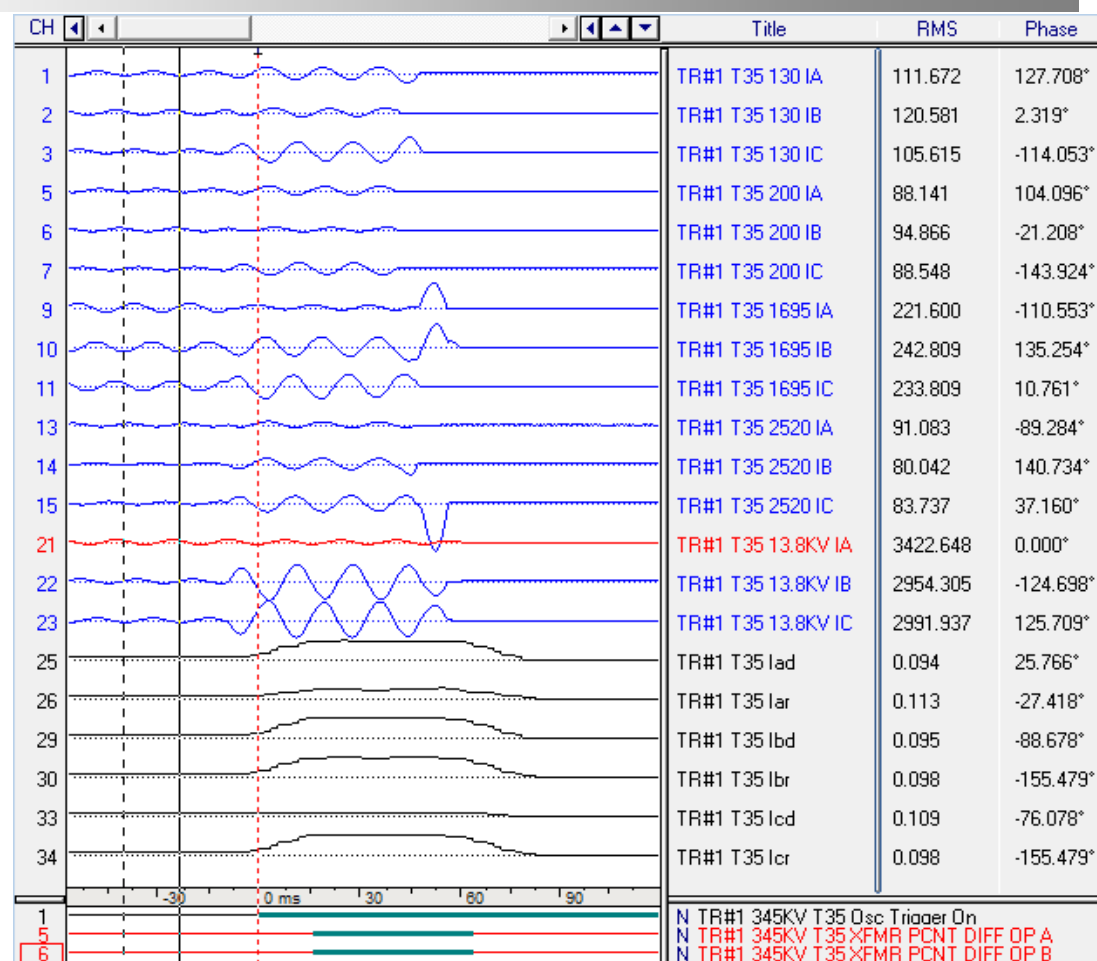
# Last CB to Clear the Remote Bus Fault

- ❖ 67N INST was not set considering loss of the Autobank feed nor by looking at the end of line fault with the Remote end open. These considerations might produce a setting that would not have tripped for this fault case.
- ❖ Is bus-tie detail in your system model?



# Transformer Differential Winding Compensation

- ❖ LLG fault on Tertiary Reactor of 345-138kV Autobank outside differential zone tripped both differential relays and beat the Tertiary 51P relay that trips Tertiary Reactor CB.
- ❖ What is the problem?
- ❖ Note that the pre-fault has differential operate currents present in all 3 phases (channels 25, 29, 33).



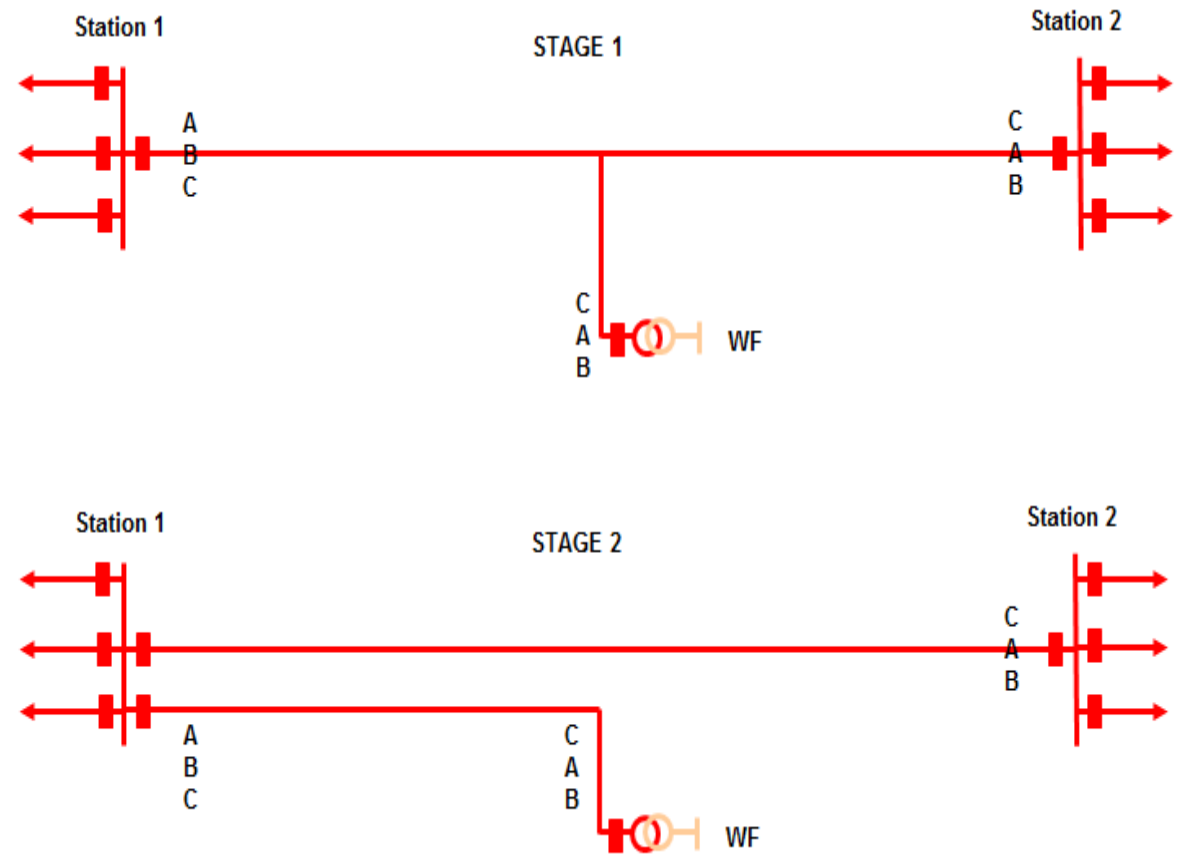
# Transformer Differential Winding Compensation

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- ❖ Cause is error in Winding Compensation settings for the Tertiary winding.
- ❖ Autobank is connected CBA; settings were for an ABC connection. Thus, the Tertiary currents are not compensated in the differential correctly.
- ❖ Why the mistake? ASPEN model was used to verify the Autobank connection instead of the station prints.
- ❖ Lesson Learned: ASPEN model should not be used to verify D-Y connections until it is verified to match the connections in the field.
- ❖ Lesson Learned: Field Technicians could have caught this by insisting on checks with Tertiary Reactor in service.

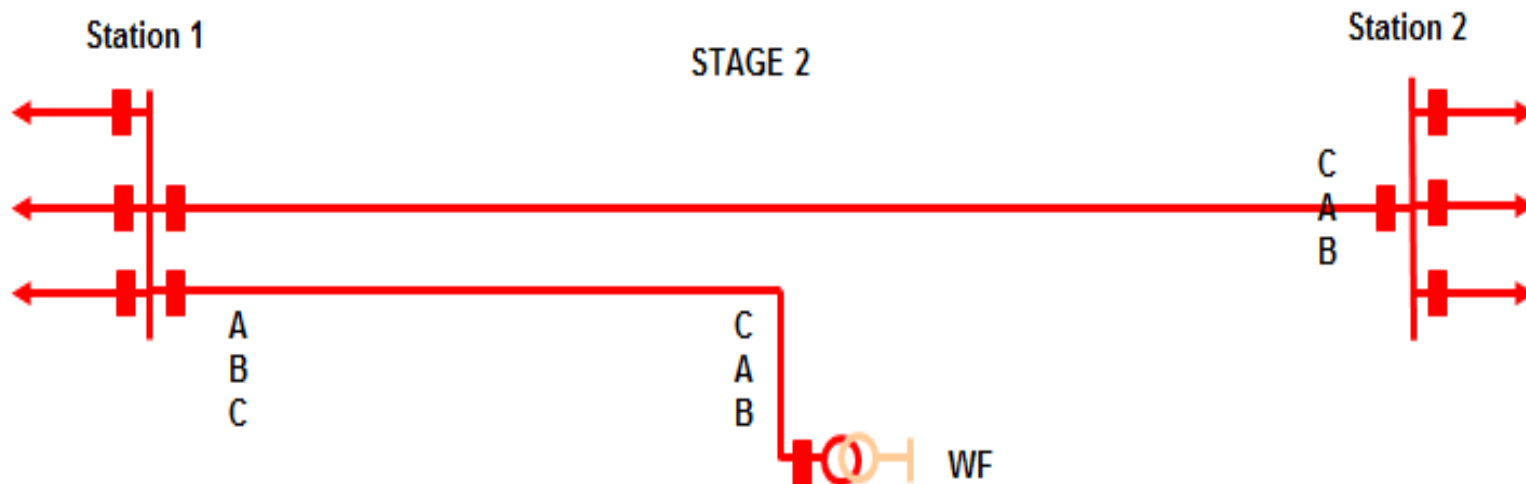
# Phase Labelling Difference

- ❖ **Stage 1: Tapped Wind Farm into line making 3-terminal DCB scheme with DTT. Everything worked correctly and somehow the PLC wave traps were on the correct phases?**
- ❖ **Stage 2: New dedicated Wind Farm line with 87L using fiber.**
- ❖ **As WF is ramping up wind turbines, the 87L relays trip.**
- ❖ **There is no voltage dip that would indicate a fault on the system, so what is happening?**



# Phase Labelling Difference

- ❖ WF relays were not setup with the capability to disable the 87L tripping function and leave backup functions in service like the AEP 87L relays. This hampers the trouble-shooting process.
- ❖ Cause is due to phase labelling difference between AEP and WF stations/relay panels and this results in 87L tripping on load.
- ❖ Phase verification tools were not used to verify phase label agreement in the project scoping stages for each location.



# Mother Nature's Critters

Can you identify the picture that is not related to a Misoperation?

