



# Diagnosing with Data

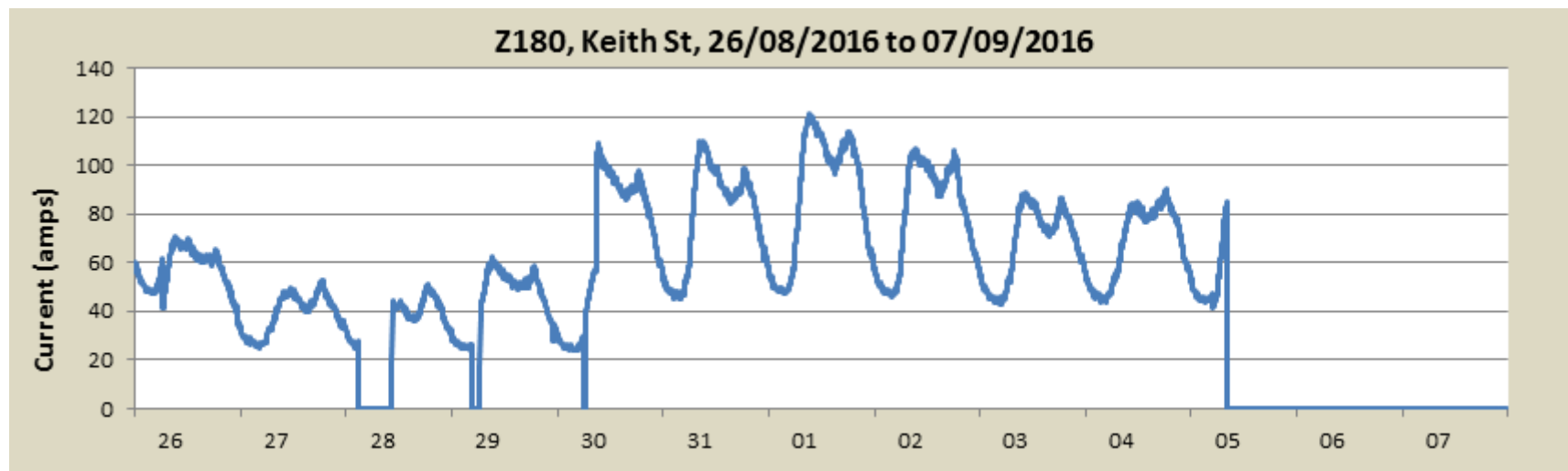
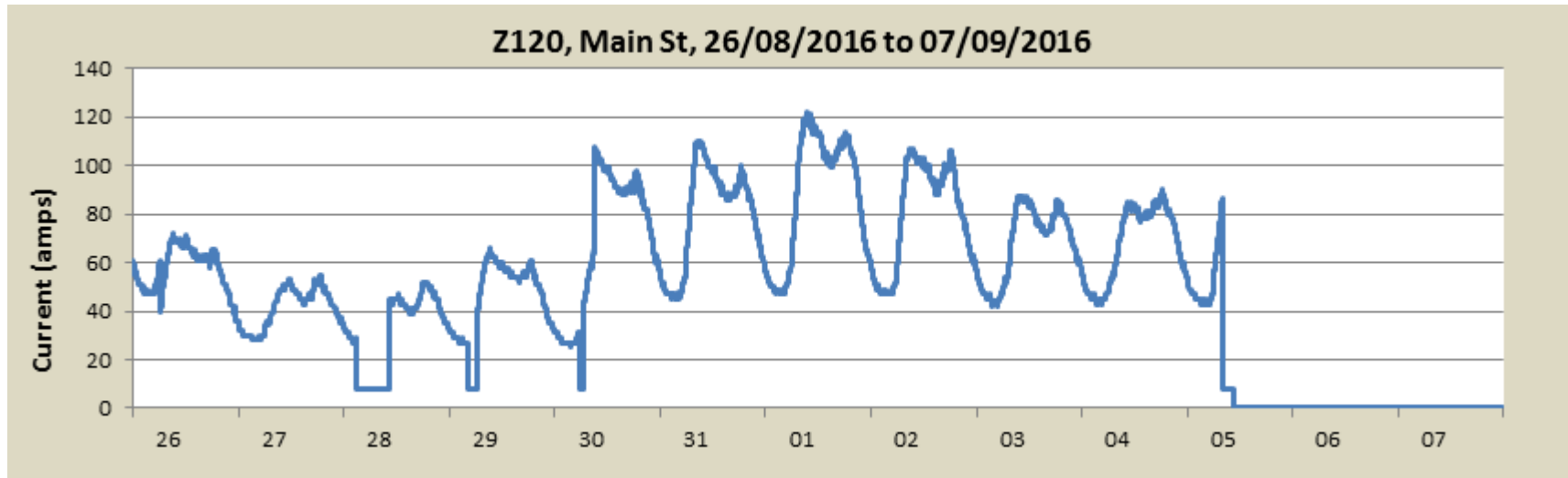
Robin Pittwood

Powerco / June 2018 / EEA AMG Workshop

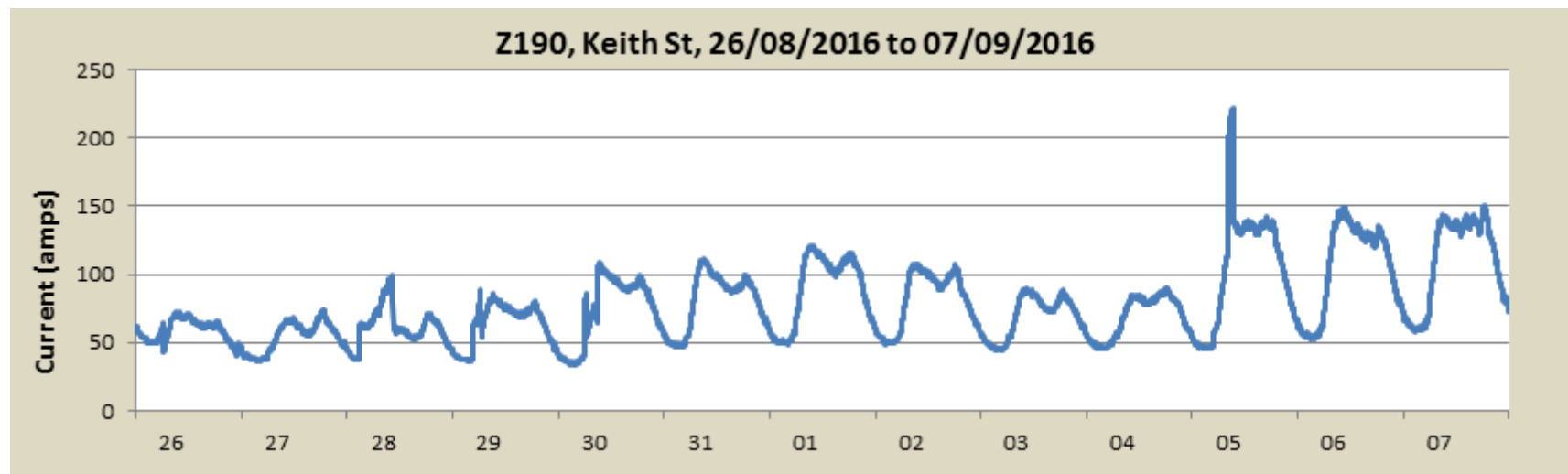
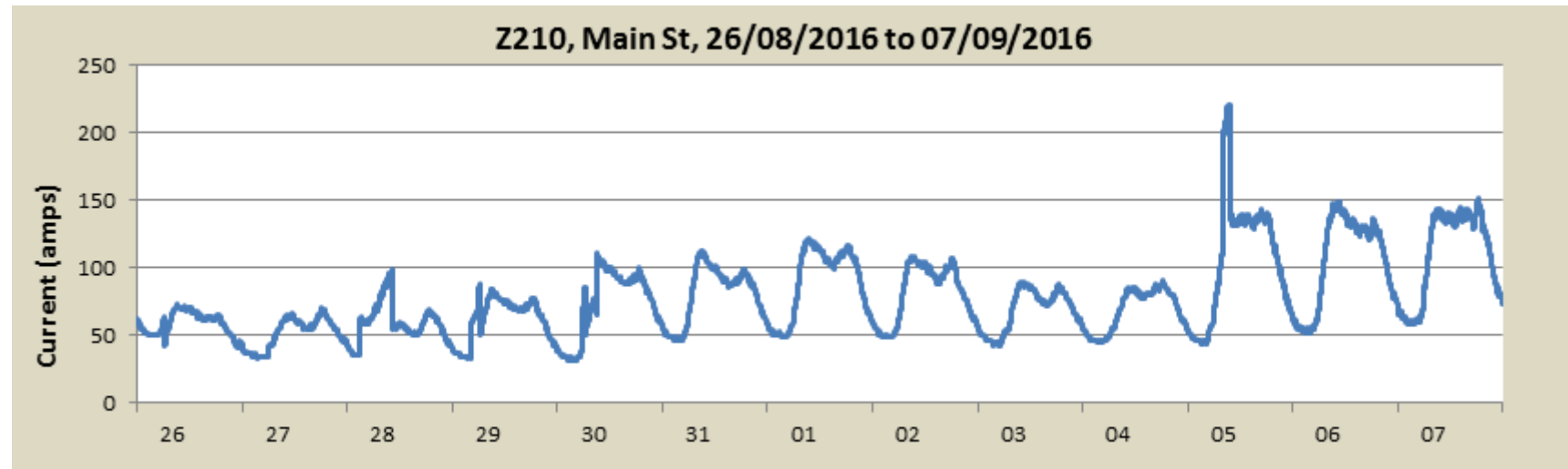
## Three examples:

- On using data, this presentation might be different from what you were expecting
  - In these cases we're not looking at general trends
  - Instead we're learning from apparent anomalies and viewing things from different angles
- Two old oil filled 33kV cables in Palmerston North operating in parallel
  - One trips
  - There's no fault current
  - Seems to be an intermittent open circuit
- A 33kV switching station outage
  - Both incomers trip at GXP source on a low level earth fault
  - Looks like a protection discrimination issue
- Tap changer performance, settings and some other observations
  - Gleaning new nuggets by observing relationships between the variables

Palmerston North cable fault – these are old oil filled cables with leaking joints  
– PI reported the current on one phase of one cable doing this ...



# Palmerston North cable fault – and PI reported the other cable doing this – picking up the load when the other cable opens

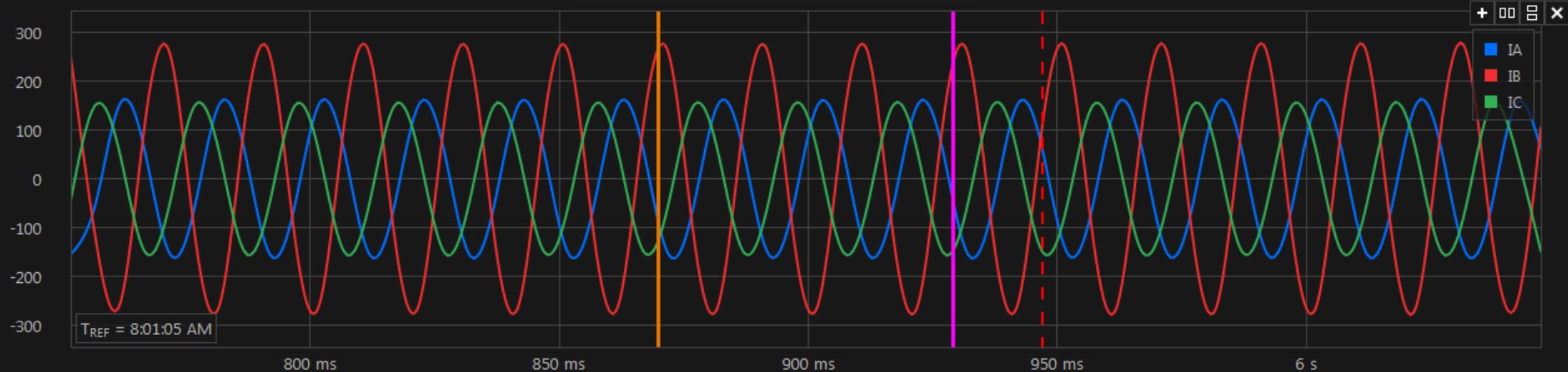


# Palmerston North, SEL traces from both cables 2 seconds before Z180 opens

**SEL** 20160905\_0801\_Keith St 33kV\_Z180 SEL-351 05Sep2016 08 01 05 733 2.cev - SynchroWAVE Event

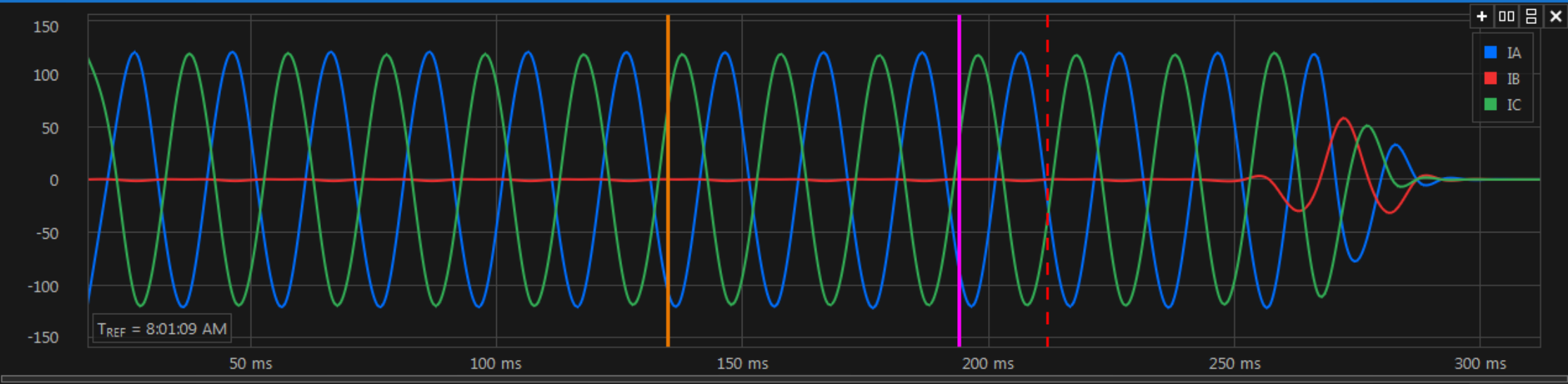


**SEL** 20160905\_0801\_Keith St 33kV\_Z190 SEL-351 05Sep2016 08 01 05 947 2.cev - SynchroWAVE Event



# Palmerston North cable fault – and the SEL trace of the trip of Z180

SEL 20160905\_0801\_Keith St 33kV\_Z180 SEL-351 05Sep2016 08 01 09 212 1.cev - SynchroWAVE Event



## Palmerston North cable fault – summary of observations

- These are old oil filled cables with leaking joint problems.
- PI shows an intermittent open circuit on one phase of one of the cables, and the other cable takes up the load.
- PI shows that when the open circuit occurs the capacitive charging current is supplied from the Main St end, implying the open circuit is near the Keith St end.
- The SEL traces show A and C phases sharing current roughly equally.
- While B phase current was carried on only one cable.
- And an observation that 1.5 cycles of current flows on B phase just before Z180 opens.



## Palmerston North cable fault ... turned out to be a ...

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- The Z180 circuit breaker was then checked thoroughly - and it was fine.
- The panel and bus connections were checked – and ...



## Palmerston North cable fault ... turned out to be a bus connector

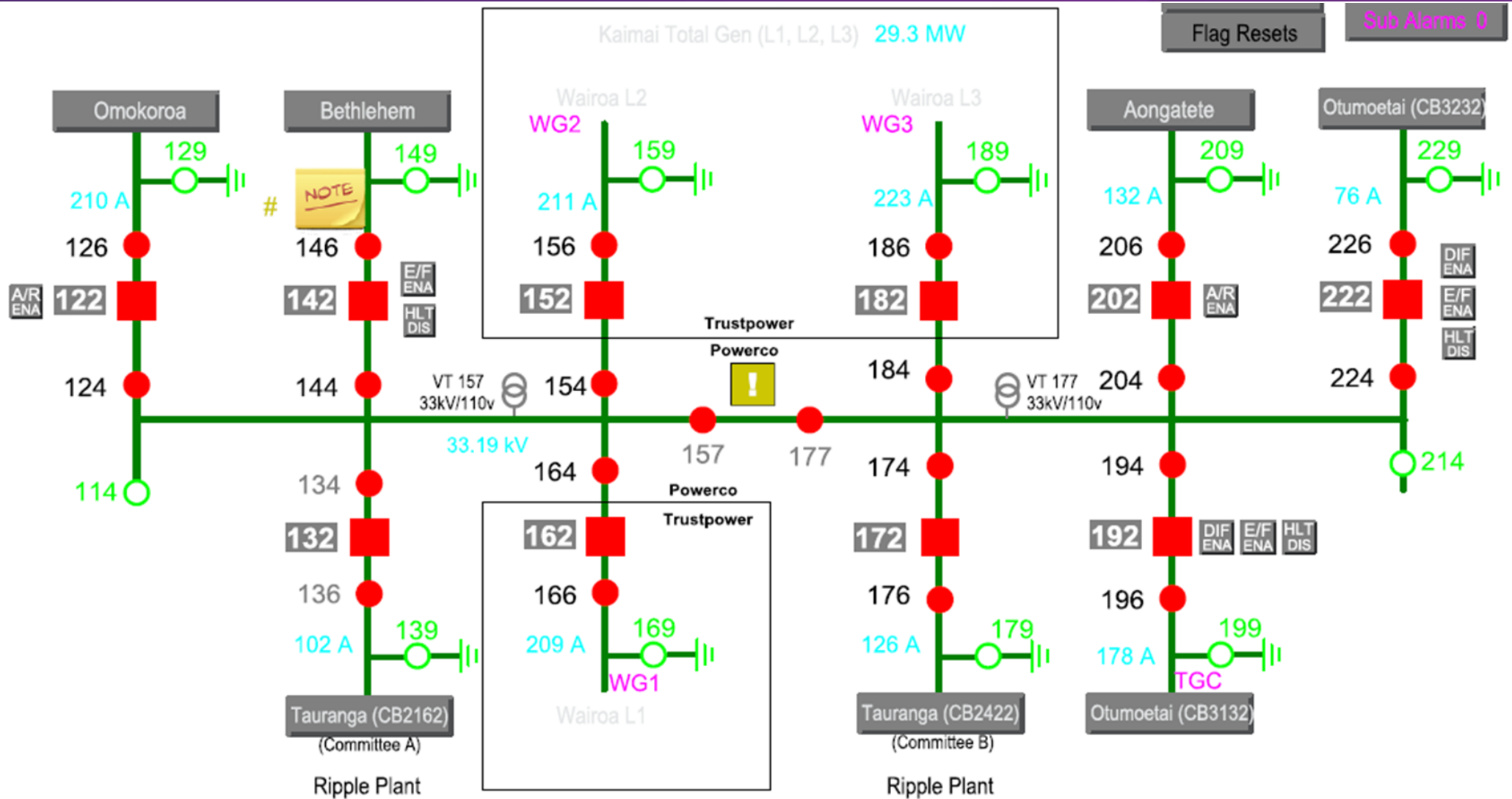
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- And an observation that 1.5 cycles of current flows on B phase just before Z180 opens.
- The Z180 circuit breaker was then checked thoroughly - and it was fine.
- The panel and bus connections were checked – and the fault was found – poorly installed bus knuckle joints.



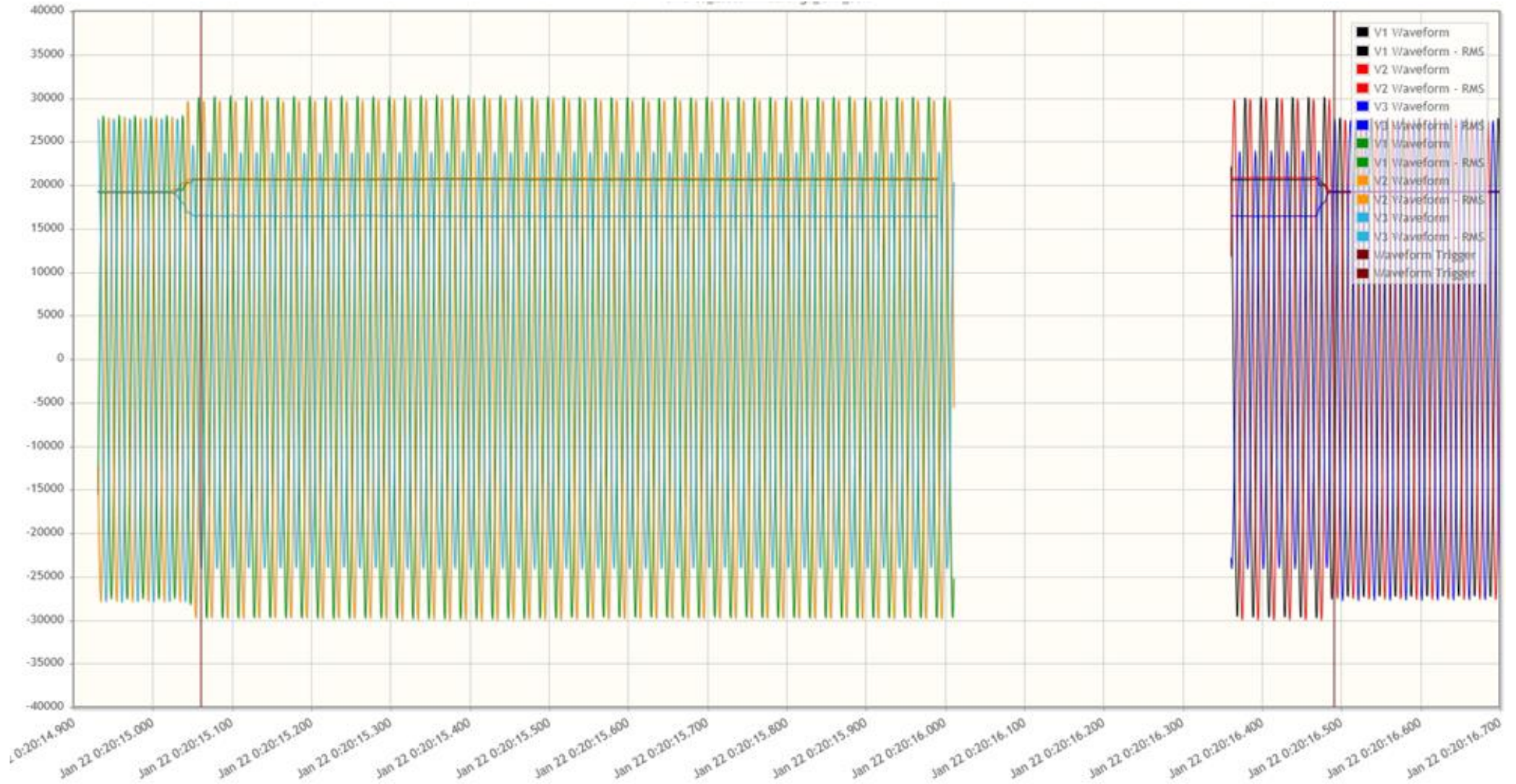
# Switching station outage

- The Substation had experienced a number of unexplained outages over several years. This investigation was for an outage that occurred on 21 Jan 2018.
- Both supplying circuit breakers at the GXP had tripped on earth fault in 1.35 sec.
- The GXP end relays also commanded the substation incoming breakers to open too.
- Three outgoing feeder circuit breakers saw earth fault current about this time, but unfortunately were not satellite clock synchronised.
- One of the three tripped. The other two did not trip.
- What happened?

# Switching station outage

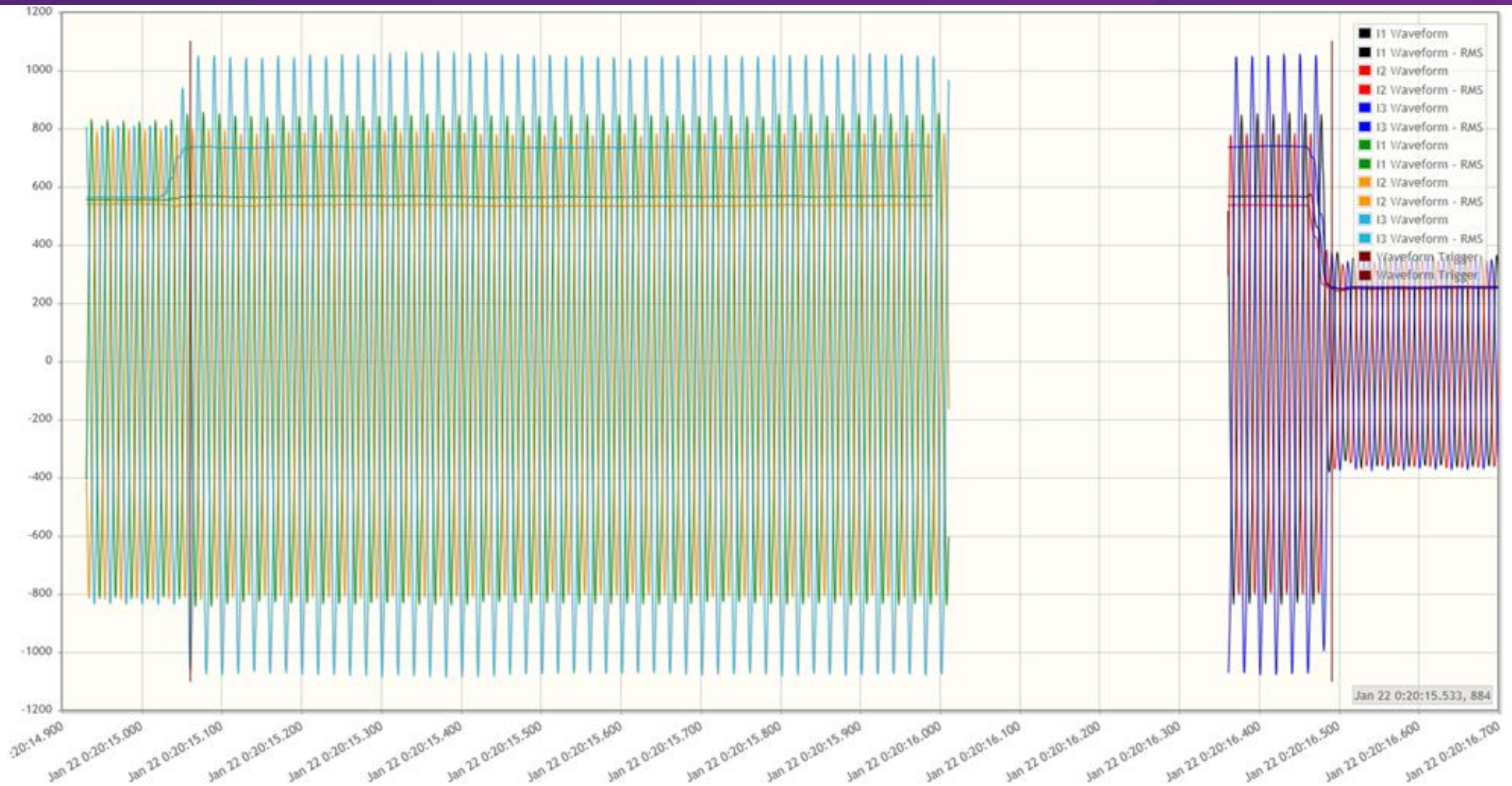


# Voltage at the GXP

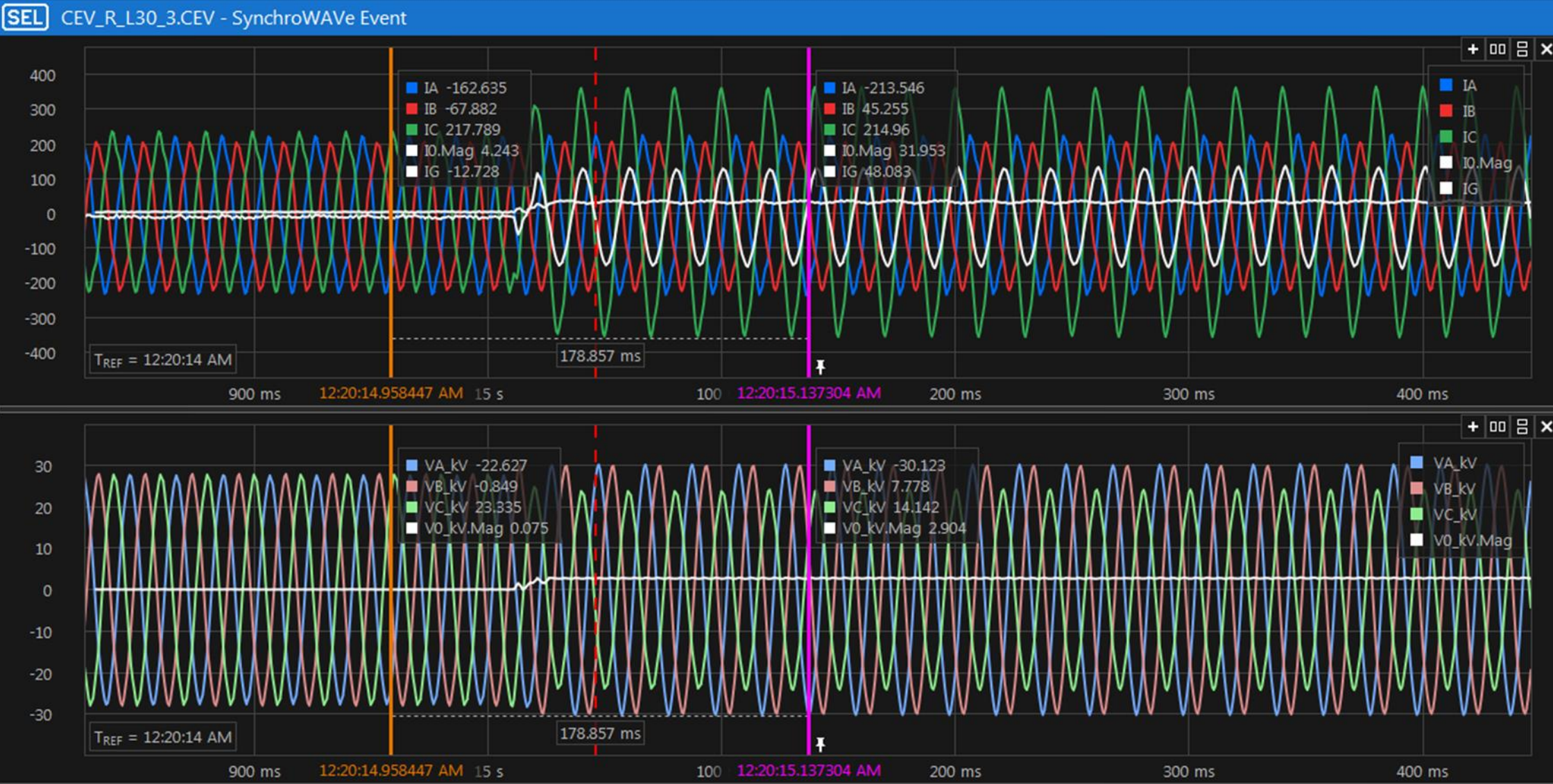




# Current at the GXP



# The circuit breakers at the GXP - highlighting Io and Vo





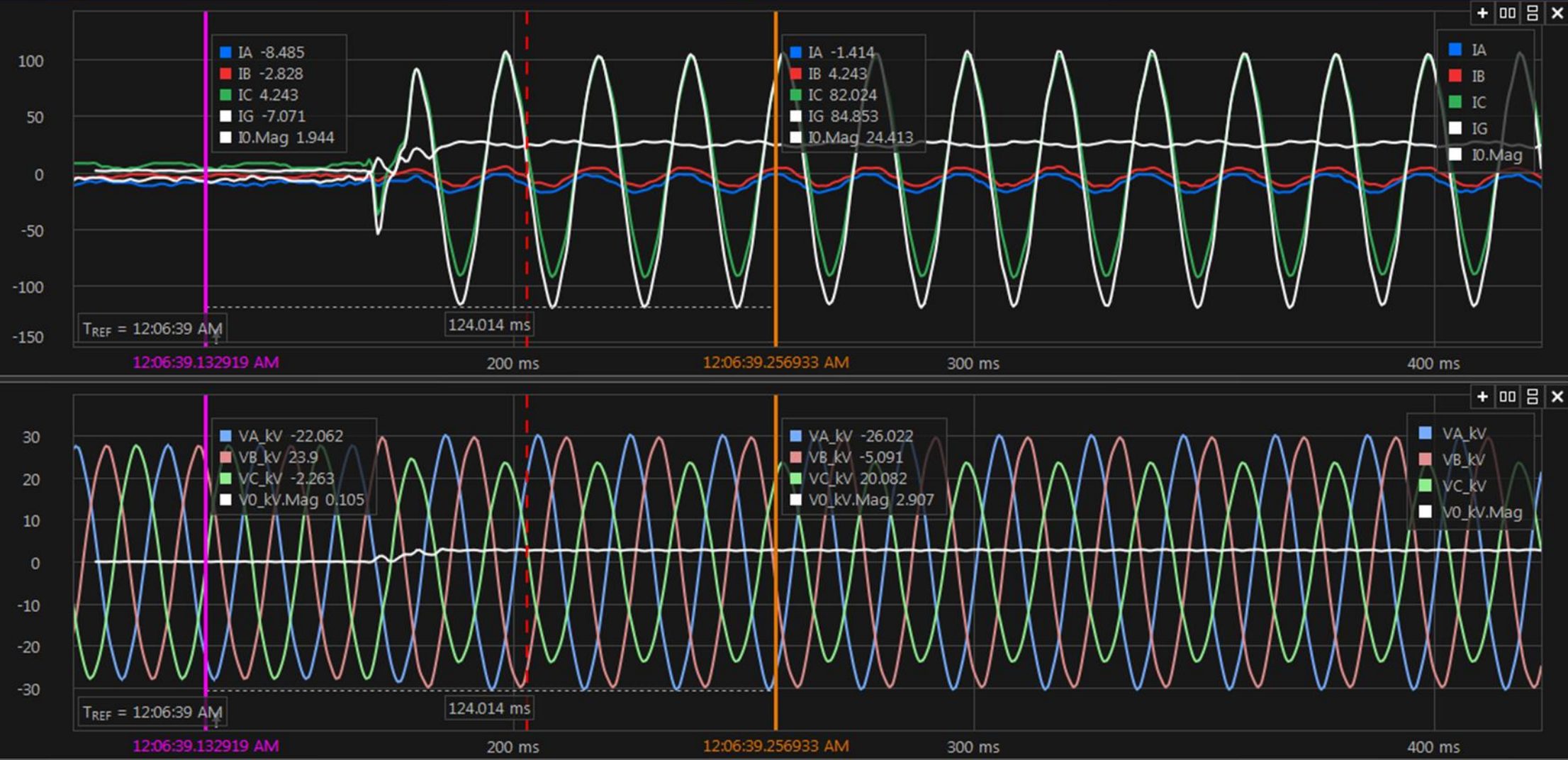
# The incoming circuit breakers at the substation





# CB182, the substation circuit breaker that tripped

SEL SQI010aa Greerton CB182 CG T 22Jan2018 00 06 39 203 CEV\_R\_L15\_3.CEV - SynchroWAVE Event

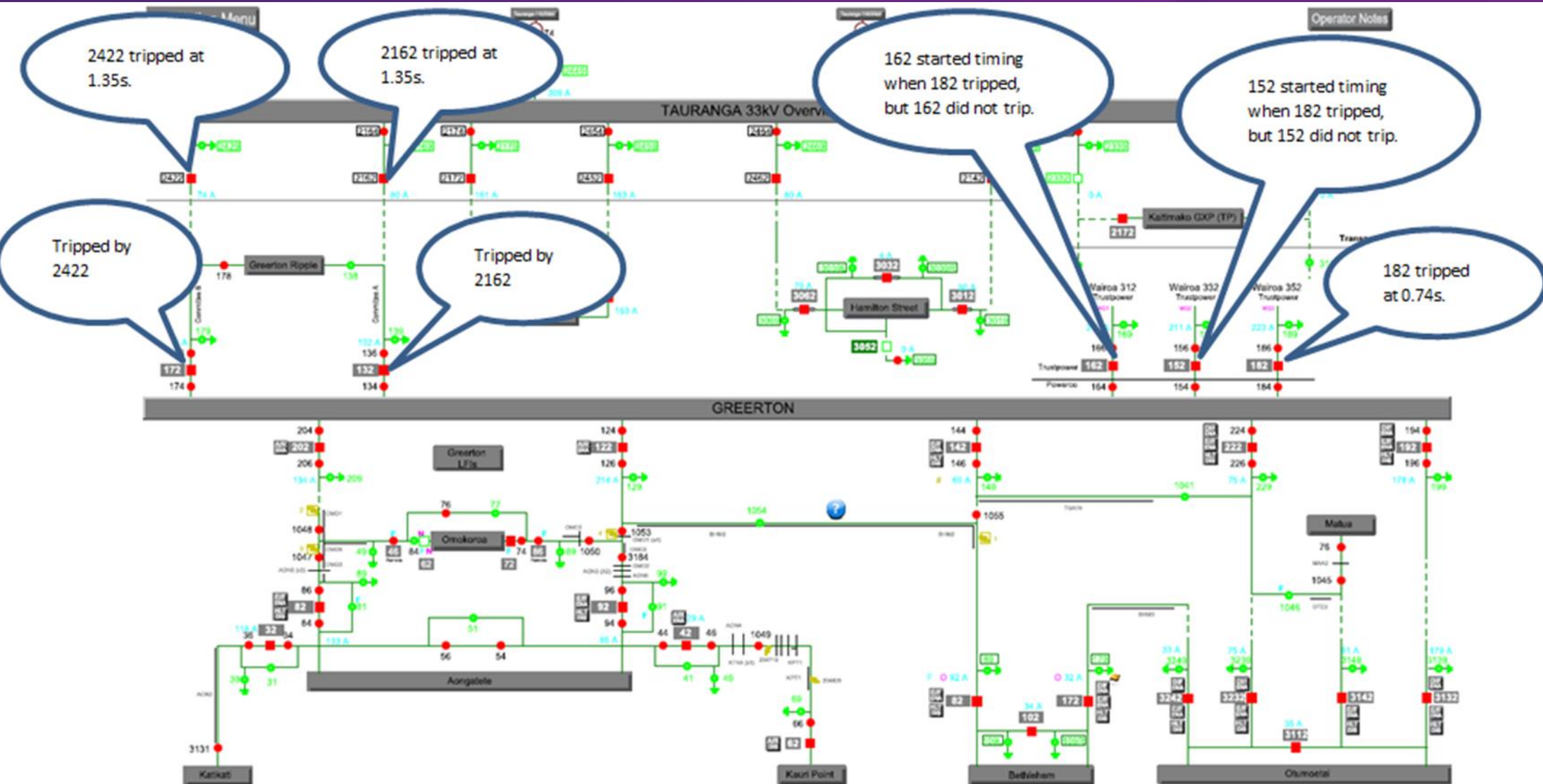


CBs 152 and 162 did not trip. They did see  $I_o$  increase which started relay timing ... however, notice that there was no increase in  $V_o$ .



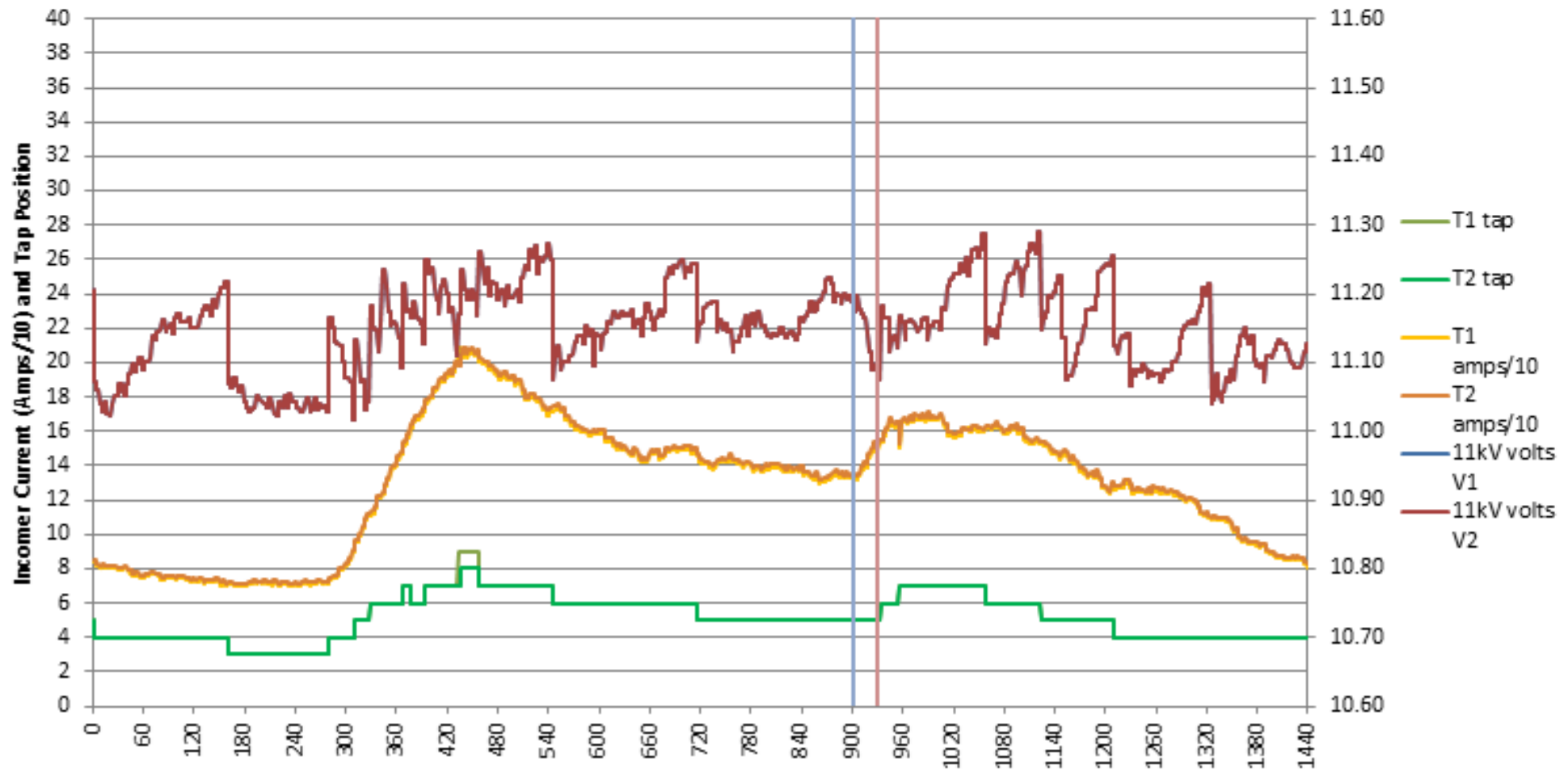


# Substation trip overview and summary



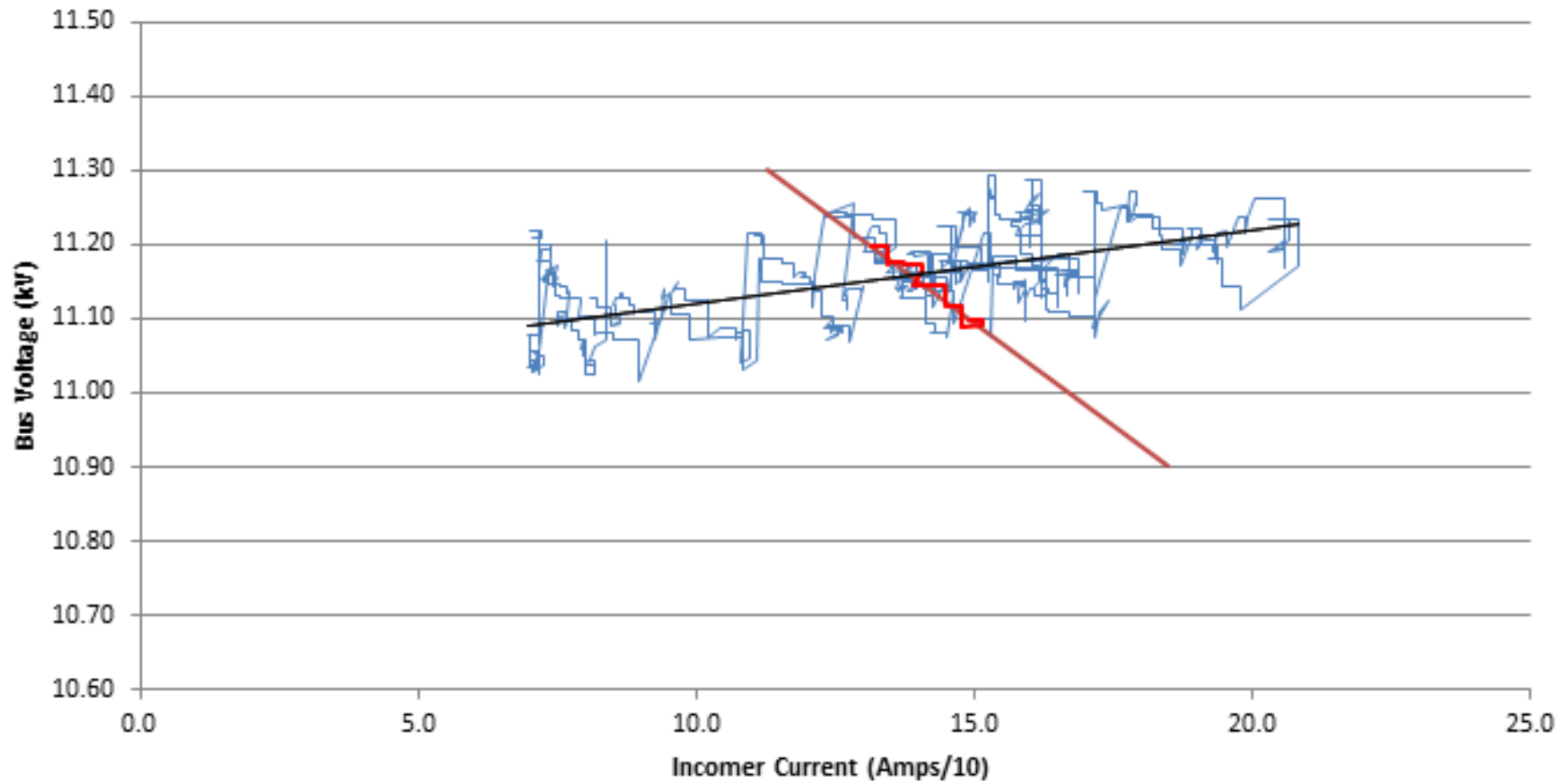
# Tap changer performance and settings – gleaning a few more nuggets ...

Kerepehi 24-1-2018 T1 Lower limit too high, Check if LDC active, Check for oversensitive BW setting,



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## Tap changer performance and settings – gleaning a few more nuggets ...

	Reading	Limits		Suggestion / comment
P1 volts	11.03	10.85	11.00	Lower limit too high,
P99 volts	11.27	11.15	11.30	
P99-P1 volts	0.24	0.15	0.3	
LDC slope	1.00	-0.5	0.5	Check if LDC active,
V1-V2 %	0.00		0.3	
Steps in bandwidth	1.0	1.4	2.2	Check for oversensitive BW setting,
Taps per day/Range	3.0	2	5	
Taps per day	18	4	20	

Impedance line	Nominal kV	11
	No of TXs	2
	Amps	kV
Upper left	113	11.30
Lower right	185	10.90
Diff	72	0.40
SC kA	3.96	
SC MVA	75	

## Diagnosing with data ...

- A 30 millisecond shake in a captured waveform led us to a switchgear fault.
- An inconsistency between zero sequence current and voltage pointed us to a cascade trip issue.
- With a little standard engineering and some standard measurements we can derive some useful system health parameters.
- Are you looking forward to applying some more imagination, incorporating improving measurement technology and analysis tools ...



The end ...



... or maybe it's just beginning ...