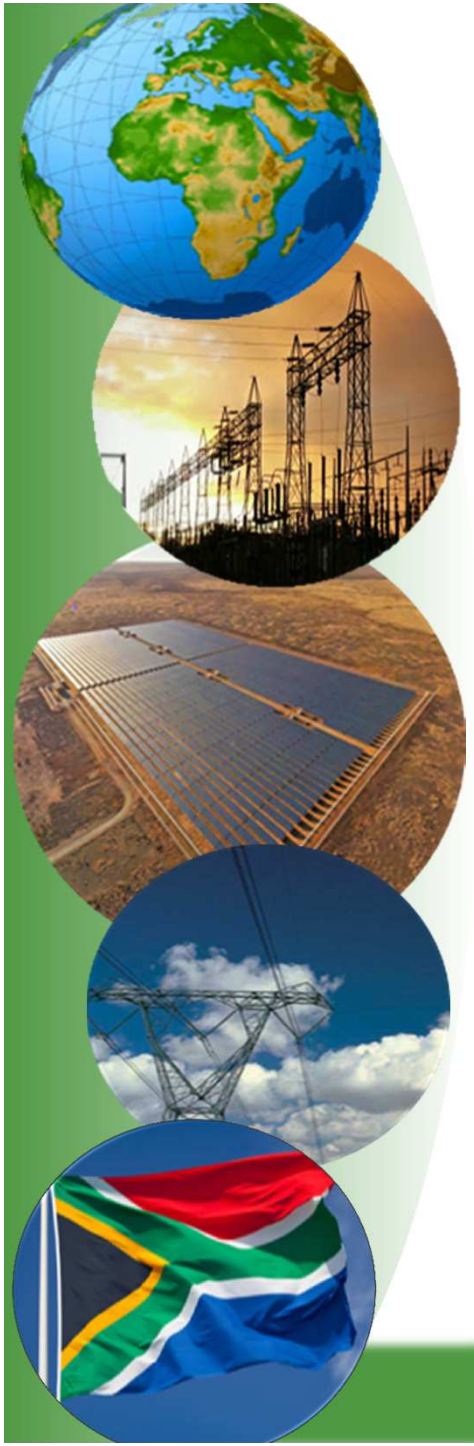

Magnetic induced currents and voltages on earthed lines due to faults on adjacent lines

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Background on earthing

When conducting work on power lines earthing practices are followed in order to protect personnel against:

- Inadvertent restoration of supply
- Static charges
- Lightning surges
- Induced voltages and currents

Background on earthing

There is a common misconception that by driving an earth spike into the ground is a sufficient way to earth an overhead line. Tests were performed to support this point whereby an earth-fault was created on a 22 kV overhead line by means of an earth spike.

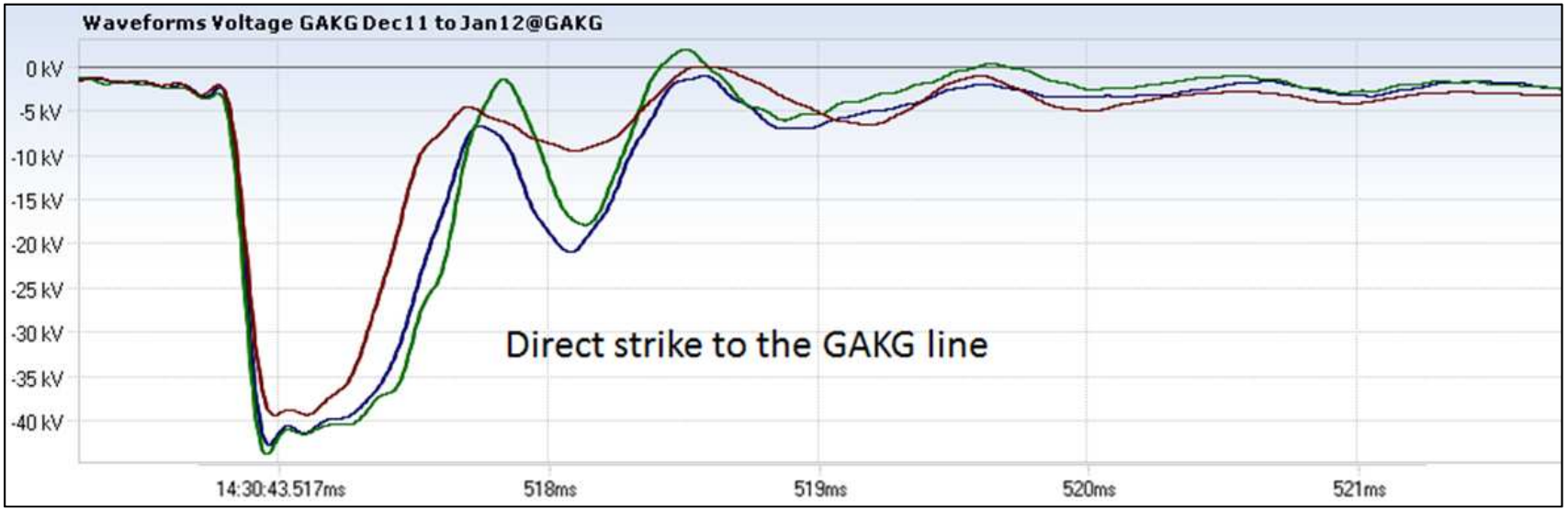
Inadvertent restoration of supply

Inadvertent restoration of supply onto an earthed section of line will result in:

- High fault currents
- High step and touch potentials around the earth spike
- High resistance earthing could lead to veld fires

Lightning surges

An example of where a dead overhead line becomes live during an 18 kA lightning strike which terminated approximately 14 km from the point of measurement is shown below.



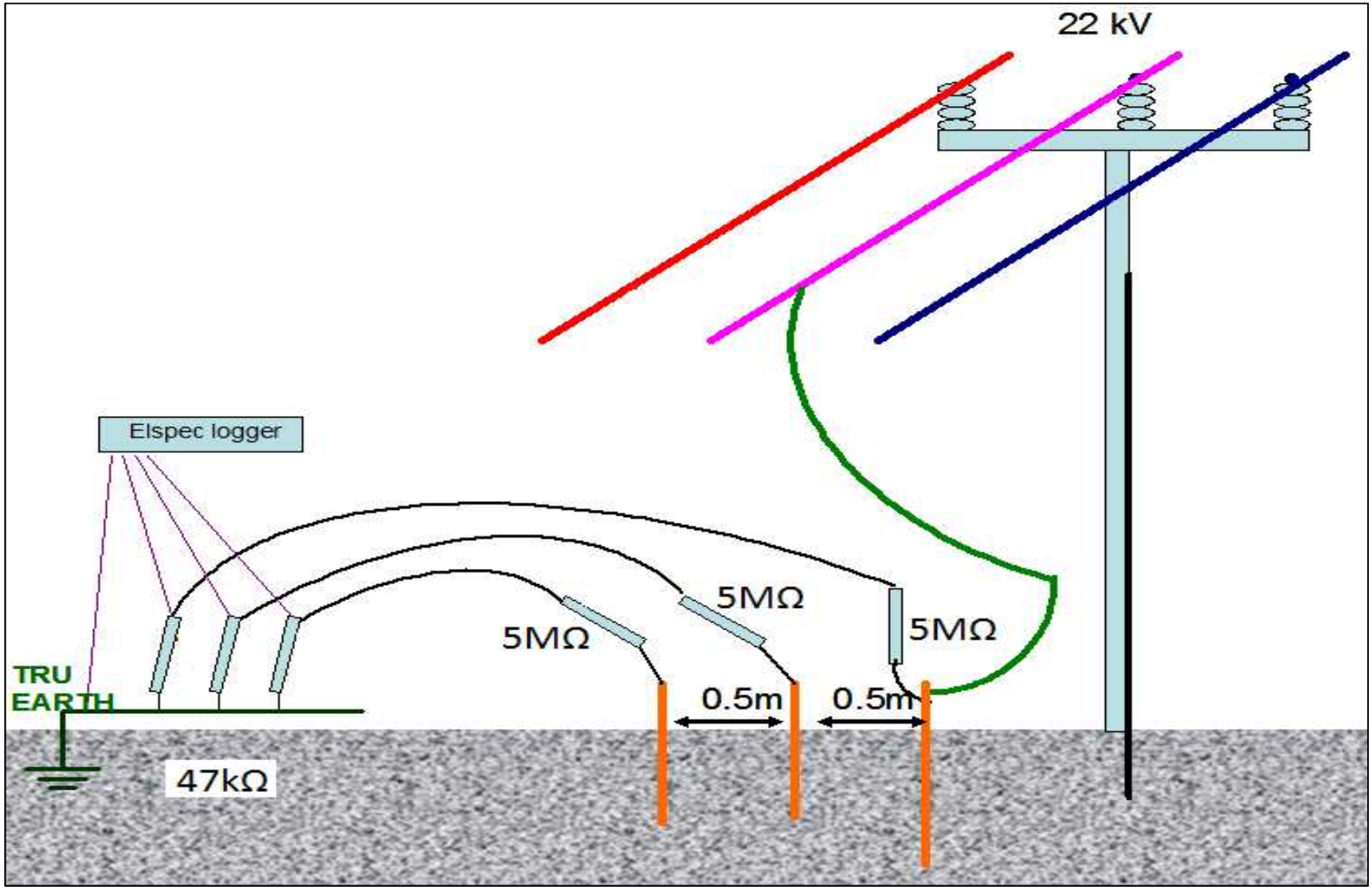
This is quite significant with regards to the safety of the public in close vicinity and personnel who perform work on overhead lines under dead conditions.

Ground potential rise

A practical test was performed in order to measure what the expected potential rise around an earth spike is:

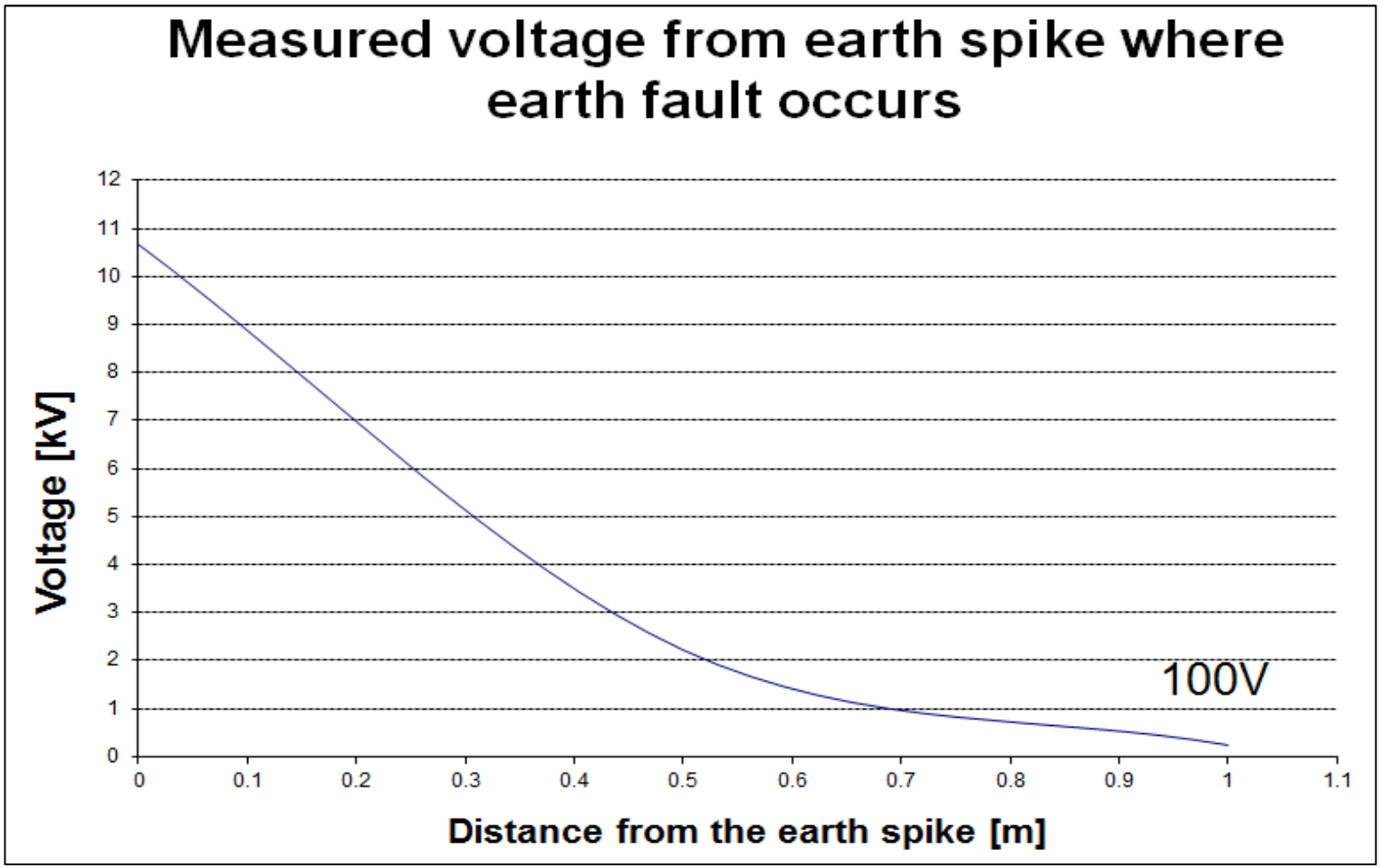
- Three earth spikes were inserted 0.5 meters apart into the earth.
- One of the three earth spikes was connected to the overhead line in order to simulate an E/F
- The voltage was recorded by making use of a resistor divider circuit

Ground potential rise – Test site overview



Ground potential rise – Results

Approximately 20% of the line phase-to-earth voltage was measured 0.5 m from the energised earth spike.



Magnetic induction - Background

Magnetic induction from one conducting medium to another, which runs in a parallel direction from each other:

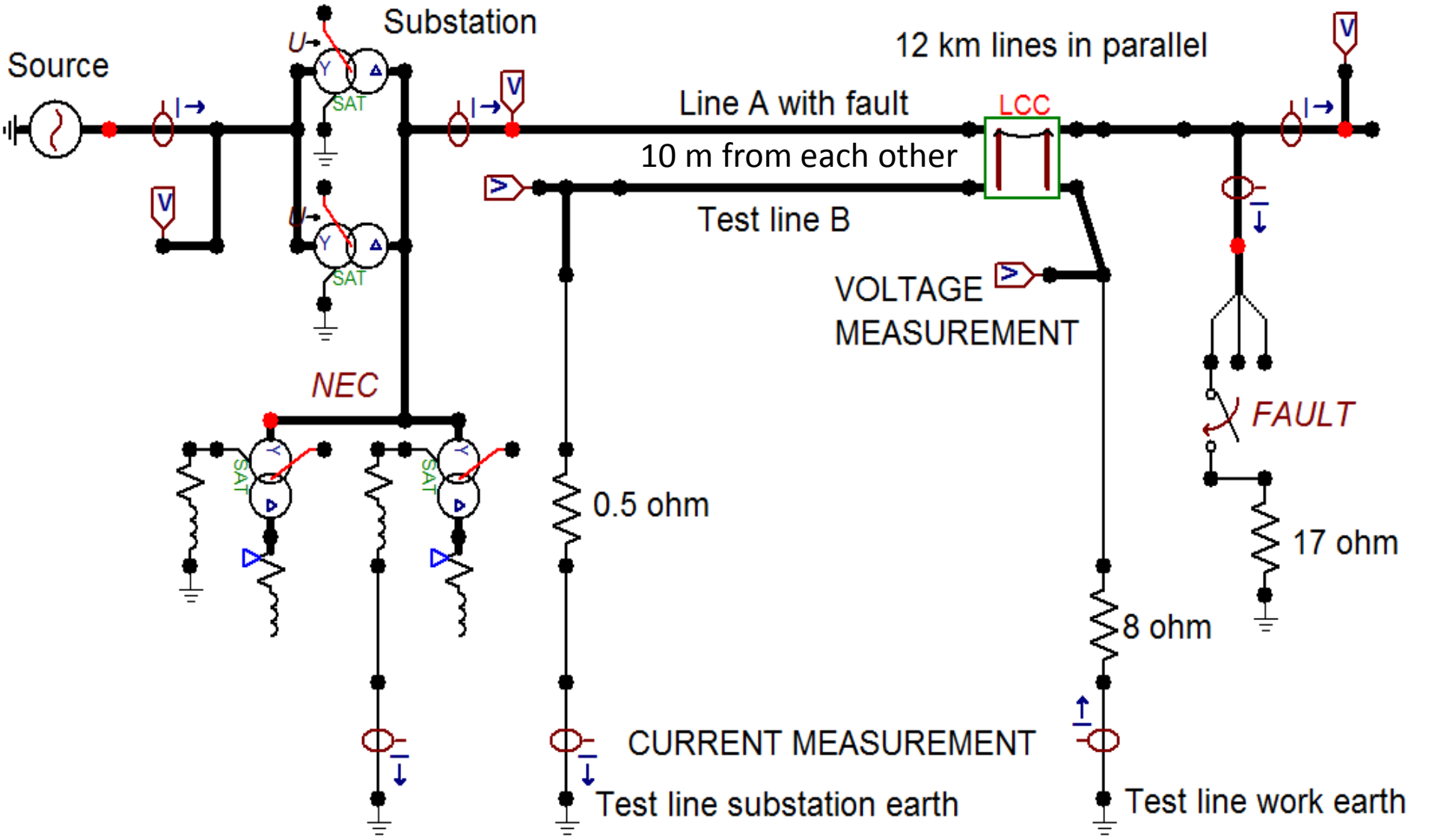
- Takes place according to Faraday's law of electromagnetic induction
- For a balanced power line the magnetic induction on a parallel circuit will be very small
- During a fault condition on a power line the high fault current will result in an induced a voltage on any nearby parallel circuit

Magnetic induced voltage - Background

The magnitude of the magnetic induced voltage between two parallel power lines are dependant on:

- The impedance of the conductors
- Distance between two power lines
- Earth resistivity
- Radius of conductor
- Length of parallelism
- Magnitude of fault current

Induced current – Theoretical case study



Magnetic induced voltage – Model verification

For the case where an E/F is present on line A, and line B is under dead condition whilst not being earthed the calculation results and simulated results correlated well:

Method used	Induced voltage
Formula - EPRI (Red book)	1378 V
Formula - ESKOM (Power series book)	1401 V
ATPDraw model	1390 V

Magnetic induced voltage – ATP model results

The effect which three earthing arrangement have on the magnitude of the induced voltage is summarised

Scenario	Magnitude of Induced voltage
No earths applied	1390 V
Control earth applied at source and working earths applied (overhead line earth at two points)	883 V
Control earth applied at the same location as the working earths (overhead line earthed at one location)	2 V

Magnetic induced voltage – Site measurements

To validate the findings suggested by the ATPDraw model, on-site tests were performed.

Site measurements - details

Overview of test site:

Fault current measured: 340A (rms)

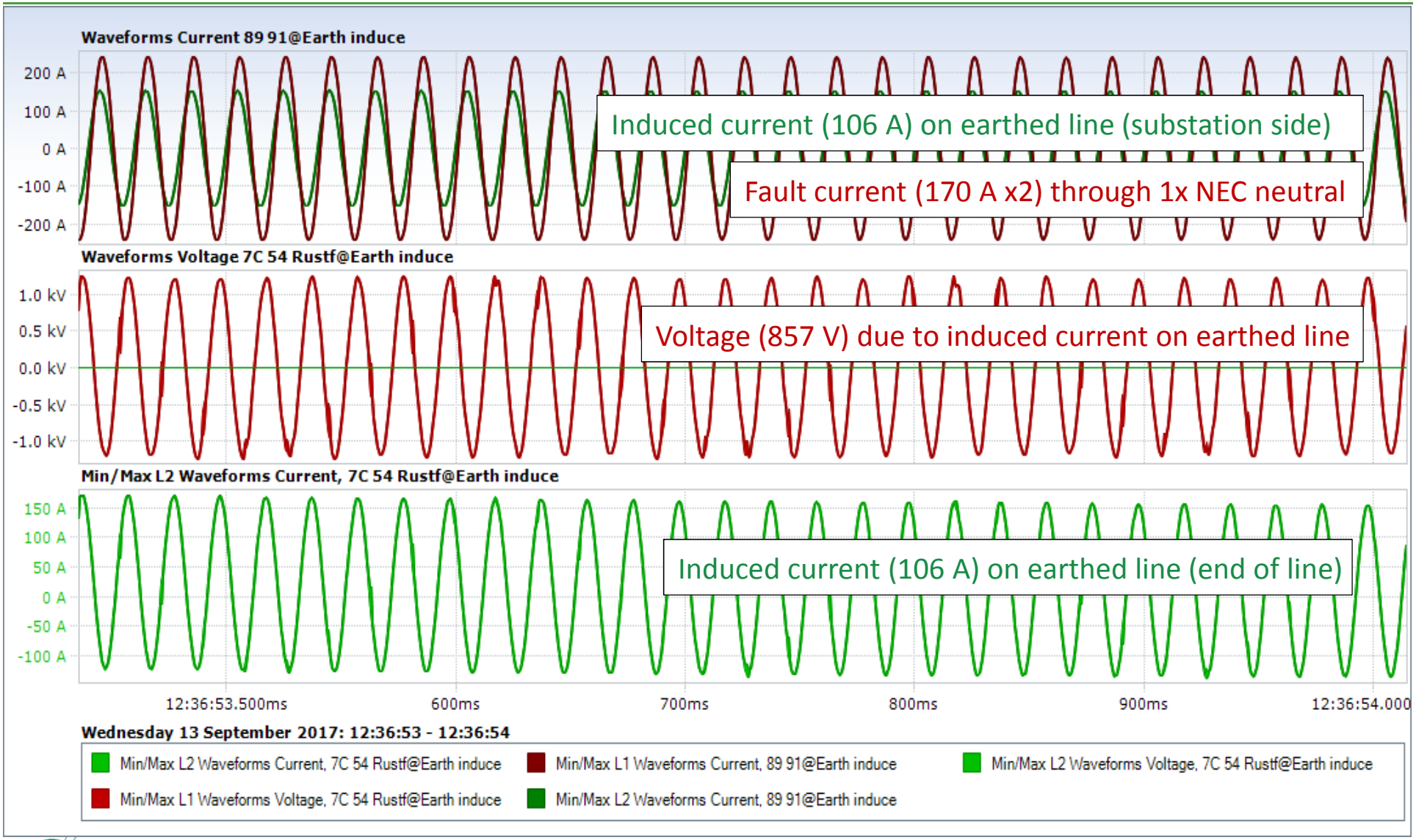
Conductor type: Hare

Distance between parallel lines: 10m

Length of parallelism: 12km

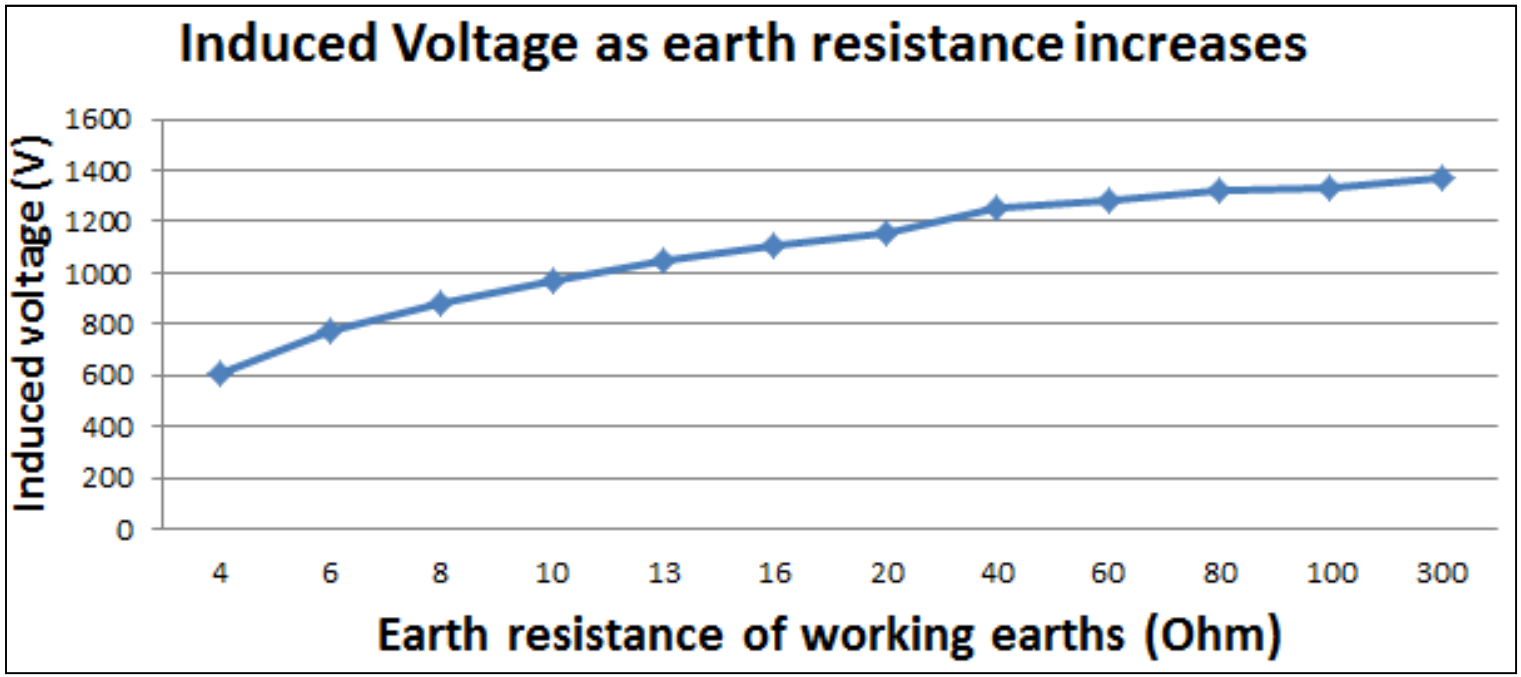
Soil resistivity 400 – 500 Ω.m

Results: Applying earths at *two locations*



Effect when increasing earth spike resistance

Effect on the magnitude of the induced voltage when increasing the earth resistance of the working earths whilst keeping the control earths at a constant value.



Conclusion and closure

- Only one earth at the workplace should be applied on feeders that runs in parallel with other feeders.
- Equipotential earthing is vital
- There is a significant potential rise on the earth spike due to earth faults – people should not be in close proximity