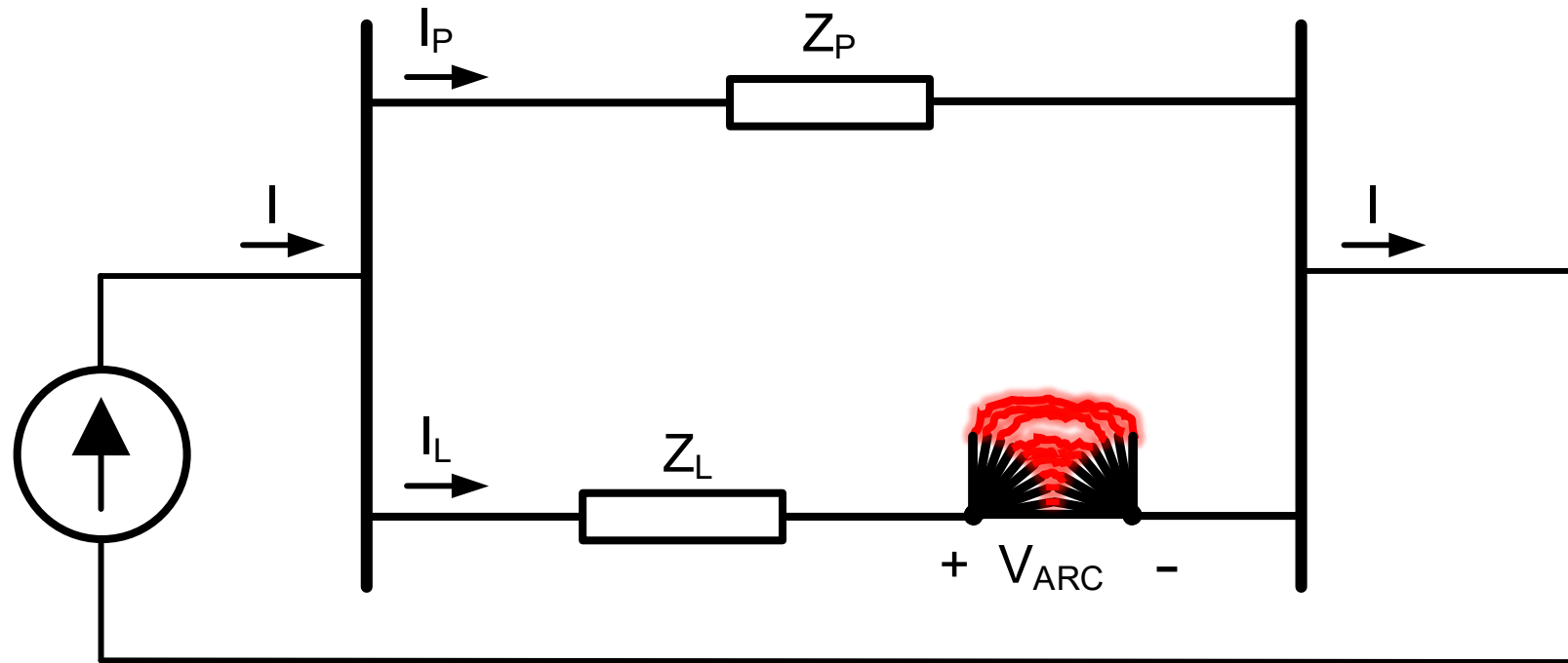


A vertical photograph on the left side of the slide shows a series of power lines and utility poles silhouetted against a vibrant sunset sky. The sky transitions from a deep orange near the horizon to a pale blue at the top. The power lines are thin and stretch across the frame, while the utility poles are more prominent, with their cross-arms and insulators clearly visible.

# Novel Methods for Detecting Conductor Breaks in Power Lines

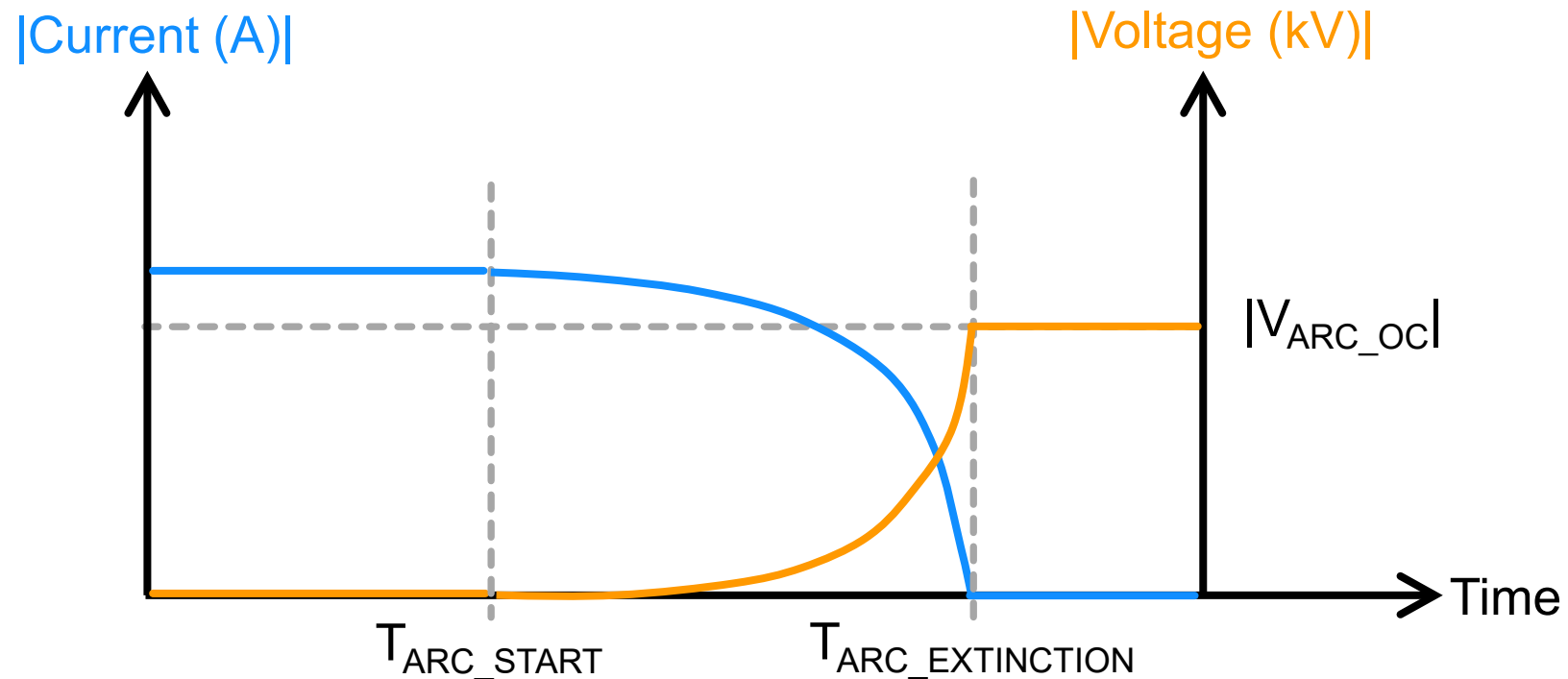
**Kanchanrao Dase, James Colwell, and Shreenivas Pai**  
Schweitzer Engineering Laboratories, Inc.

# Series arcing through disconnect switch



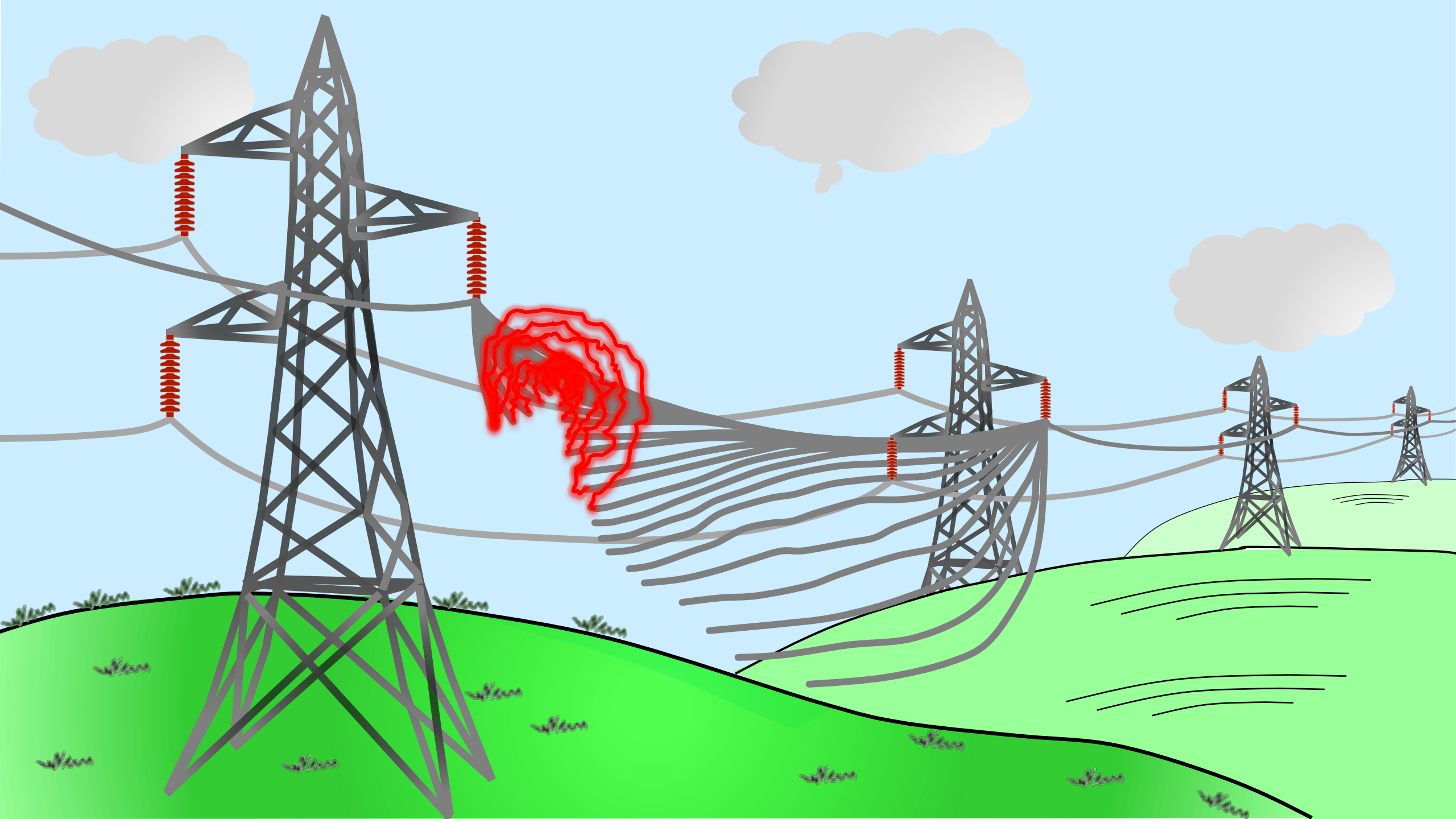
$$V_{ARC\_OC} = I_P \cdot Z_P = I \cdot Z_P$$

# Series arcing through disconnect switch

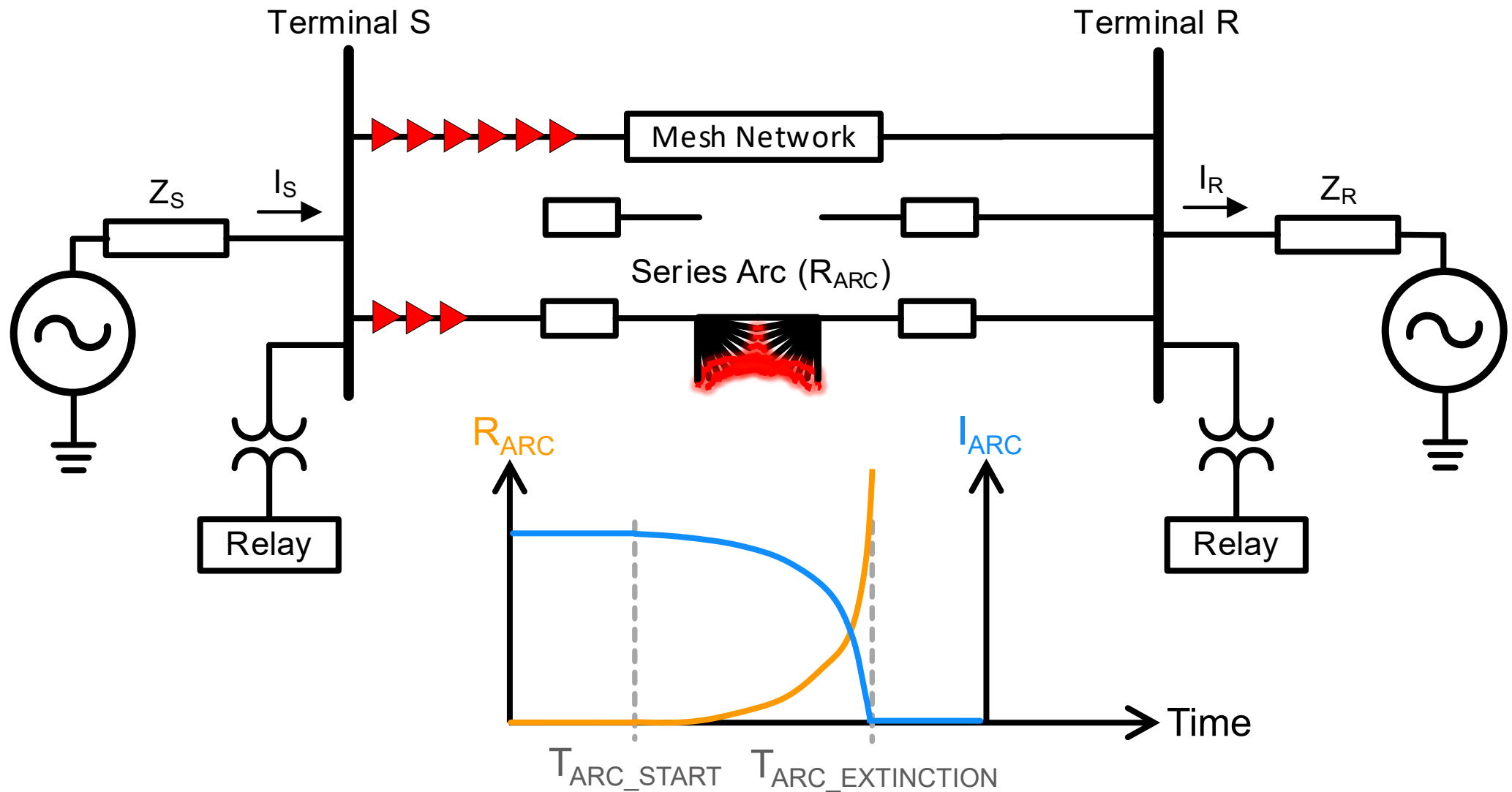


— Current through series arc

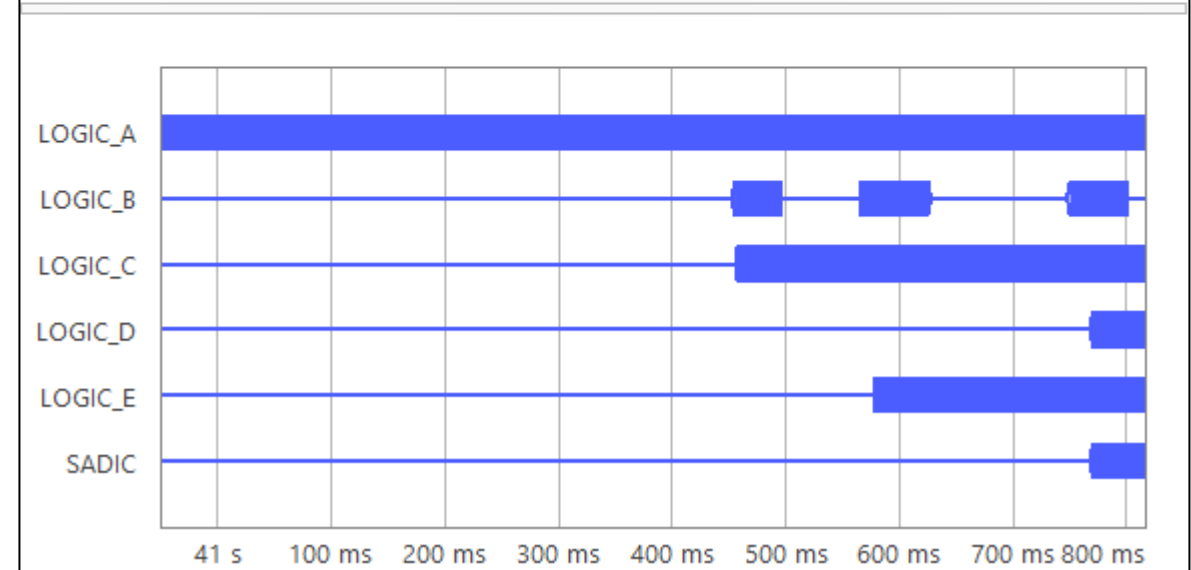
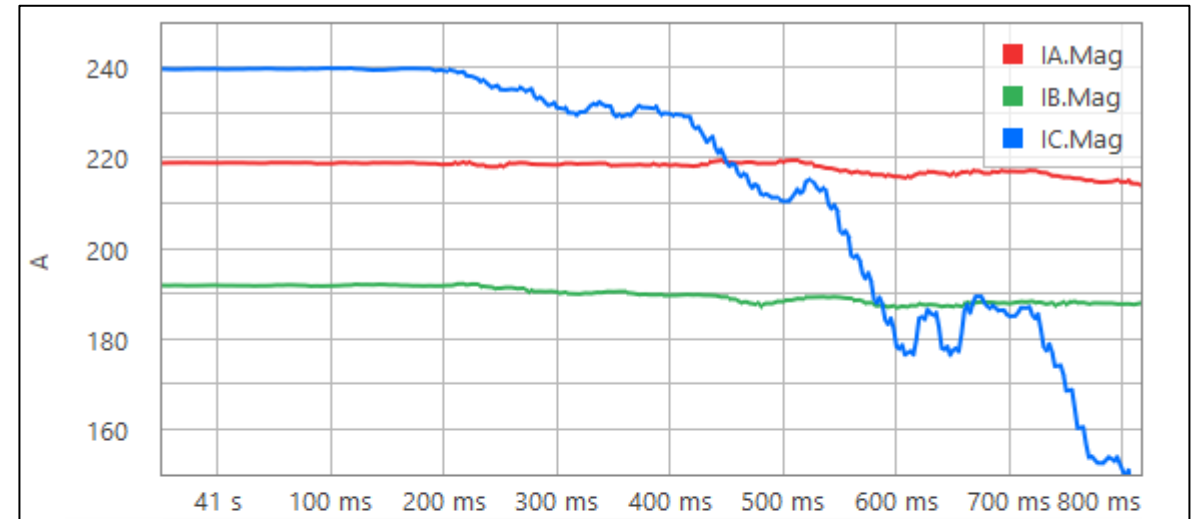
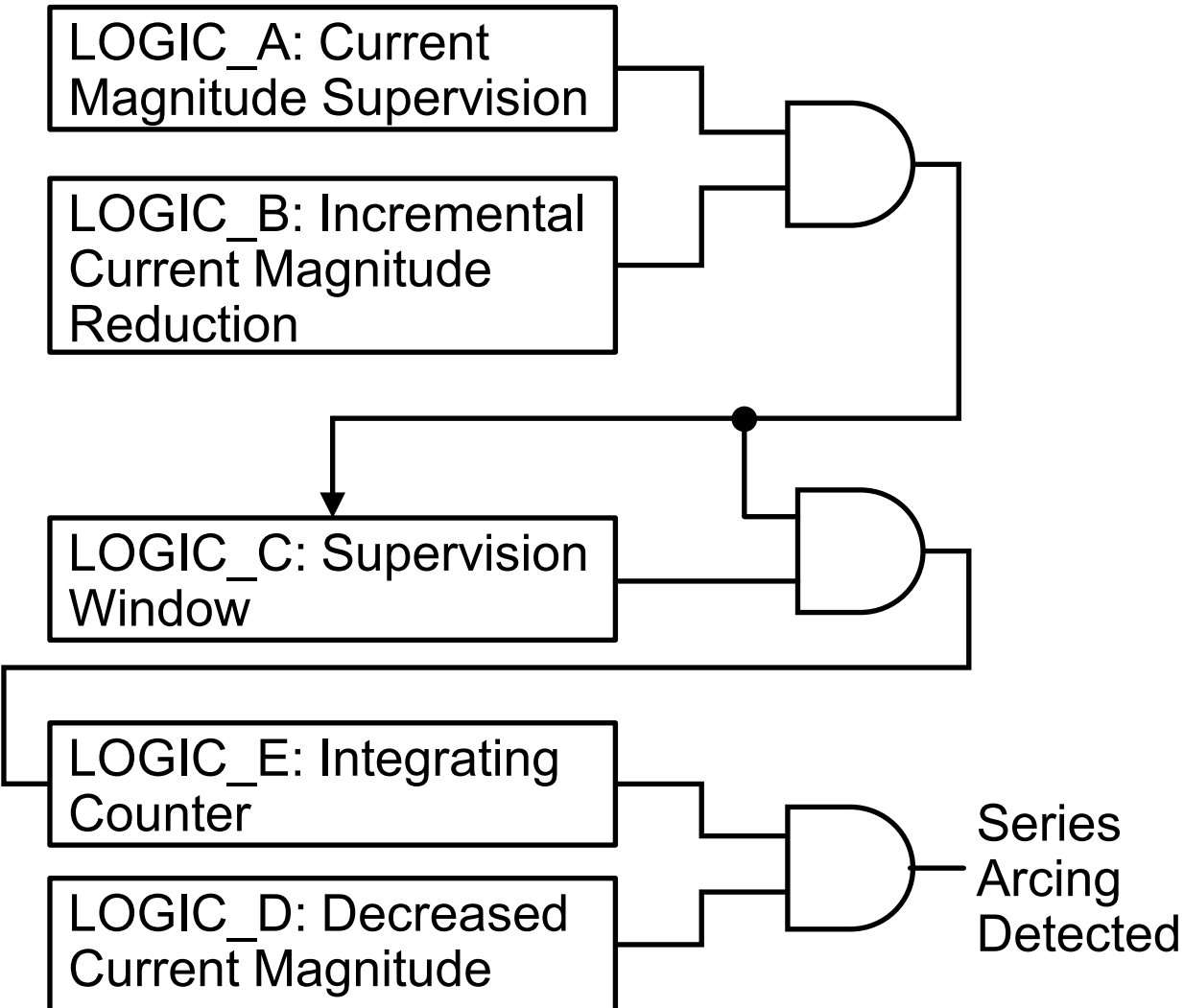
— Voltage across series arc



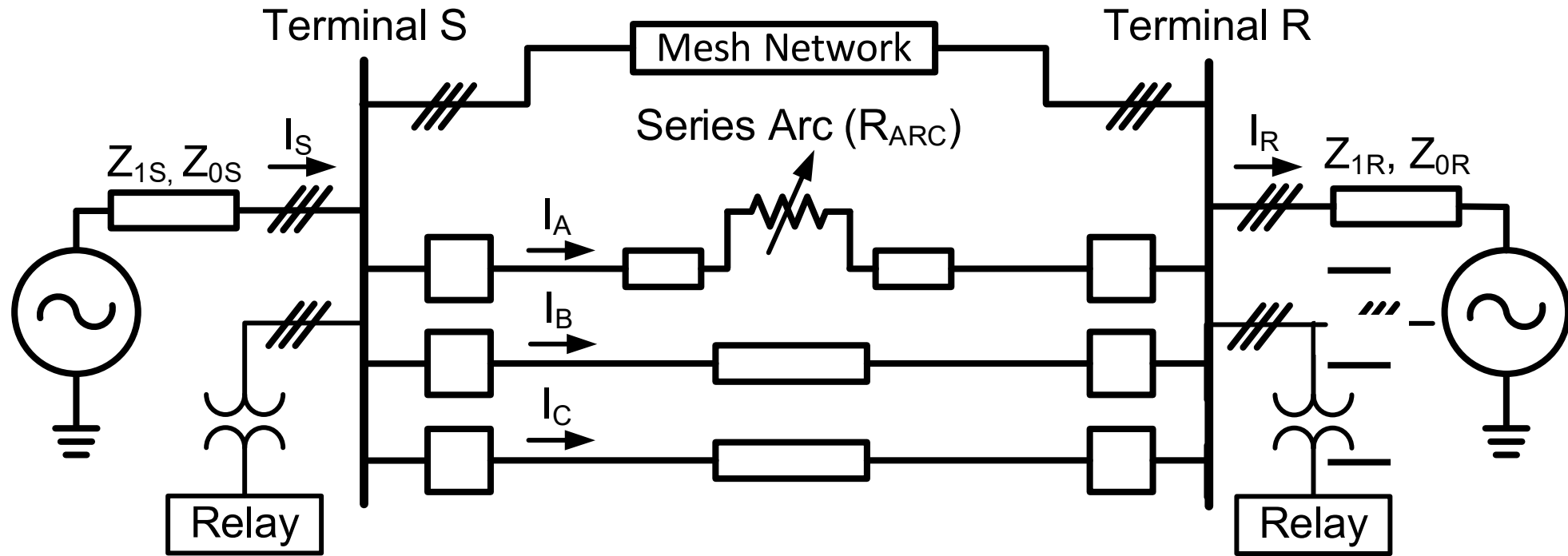
# Series arcing in a power line



# Detecting series arc through current reduction

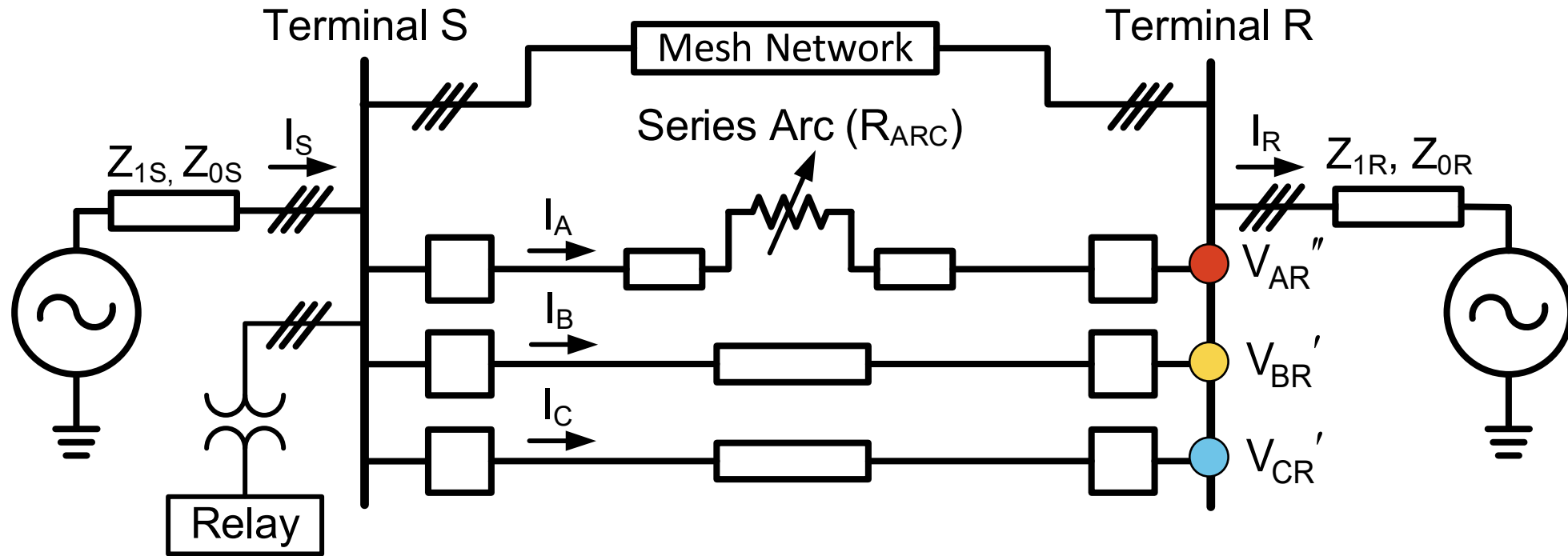


# Double-ended approach of estimating phase resistance



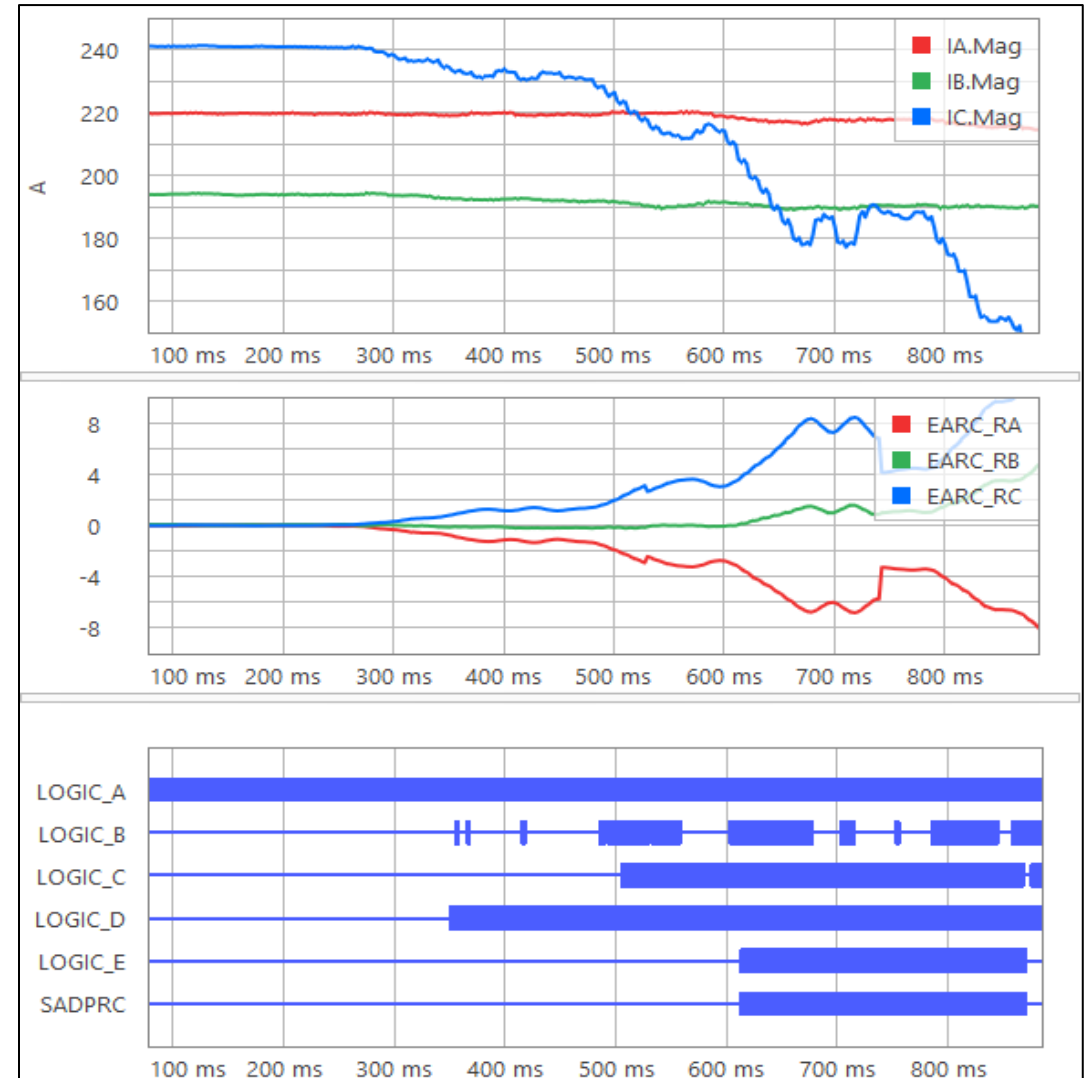
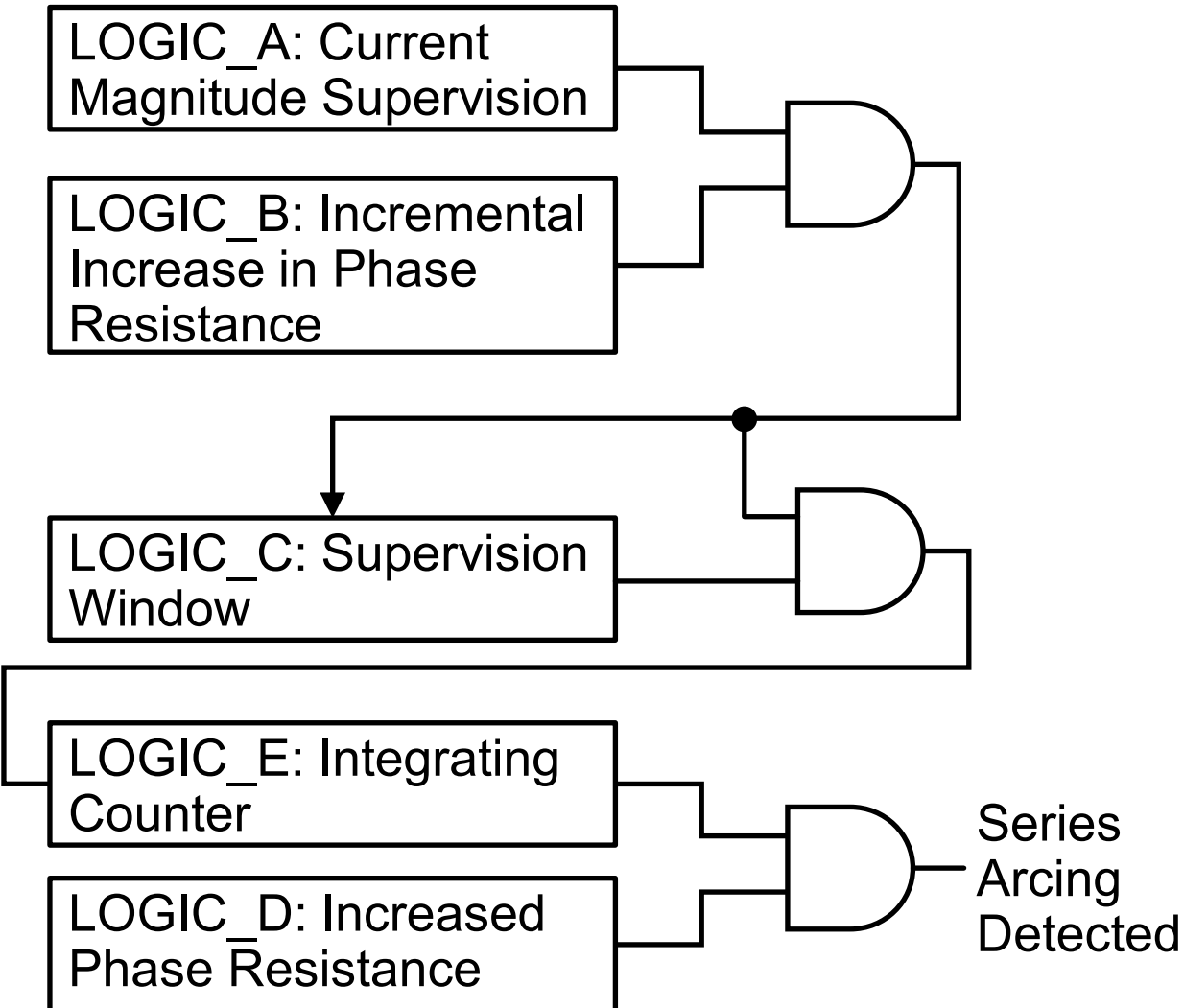
$$R_{A\_EST} = \text{Real} \left( \frac{V_{AS} - V_{AR} - (I_B + I_C) \cdot Z_M}{I_A} \right)$$

# Single-ended approach of estimating phase resistance



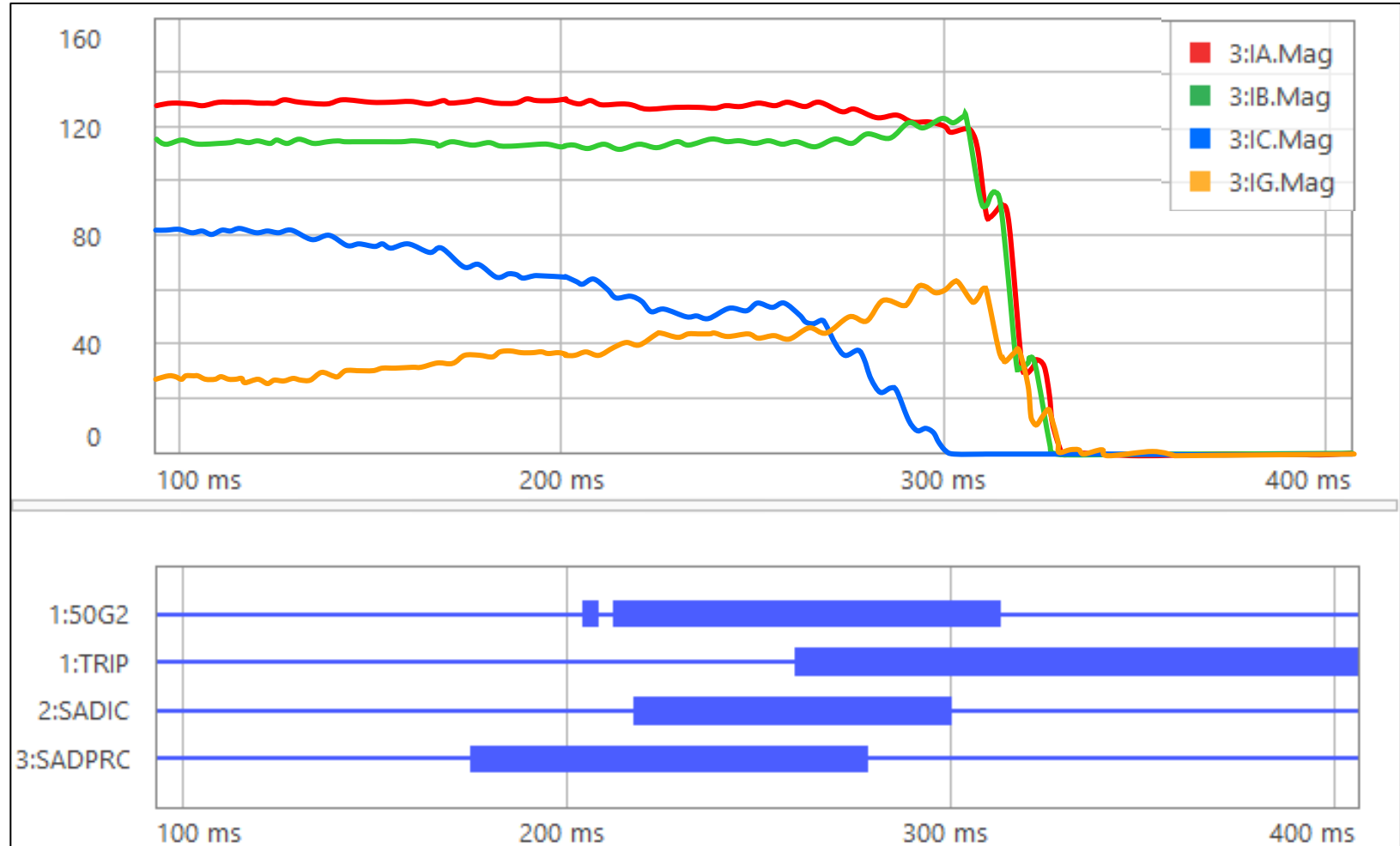


# Detecting series arc through the estimation of phase resistance



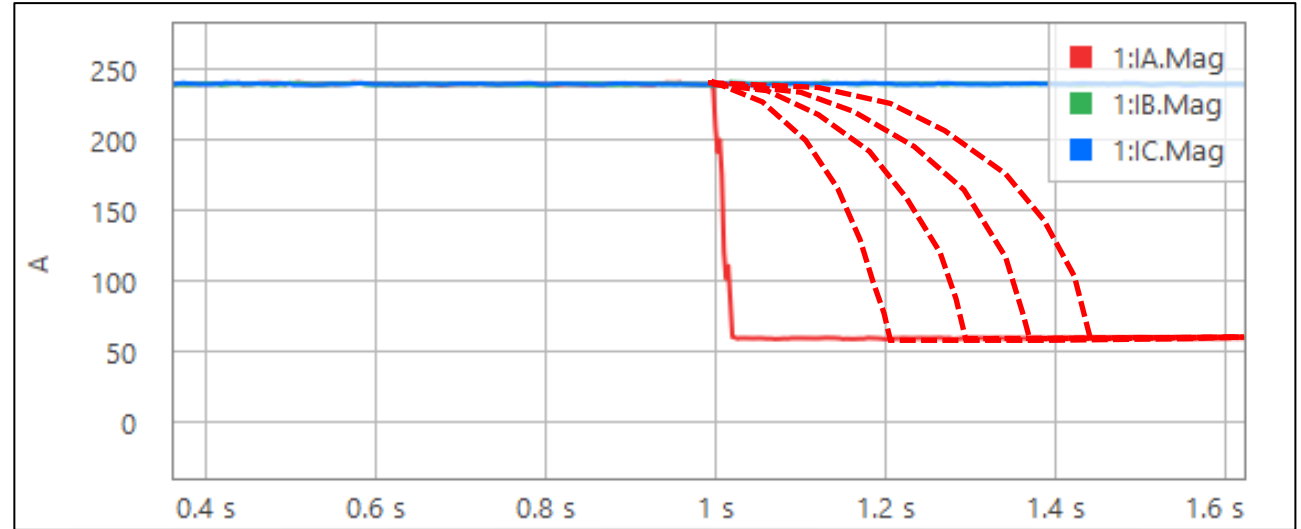
# Benefits of the proposed methods

- Single-ended methods
- Early detection of broken conductor

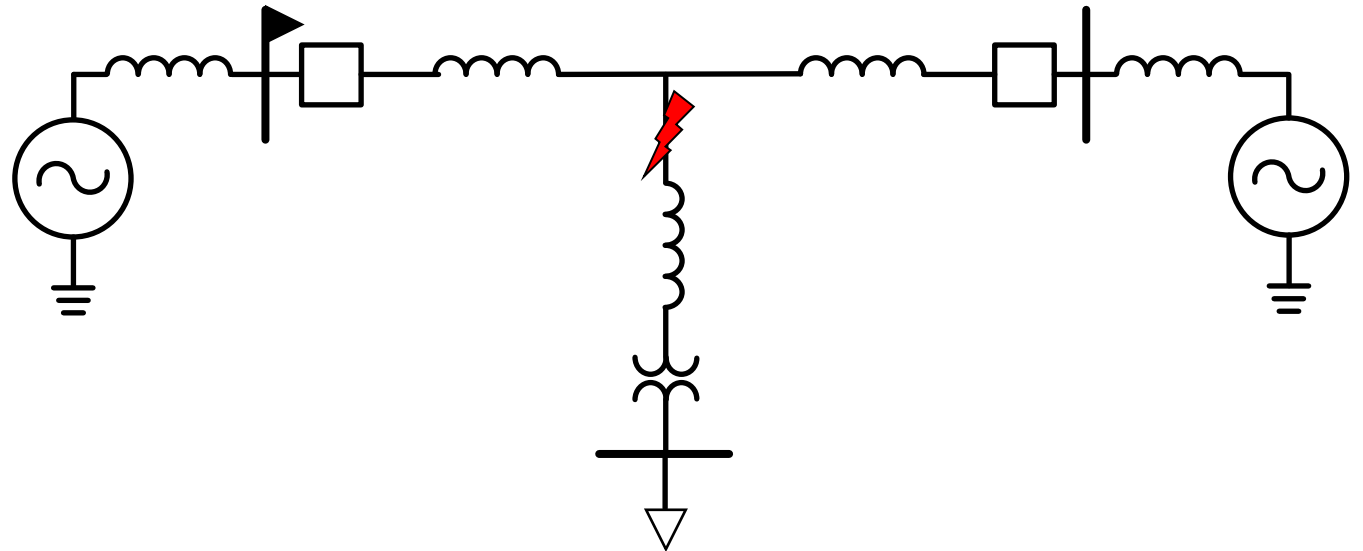


# Benefits of the proposed methods

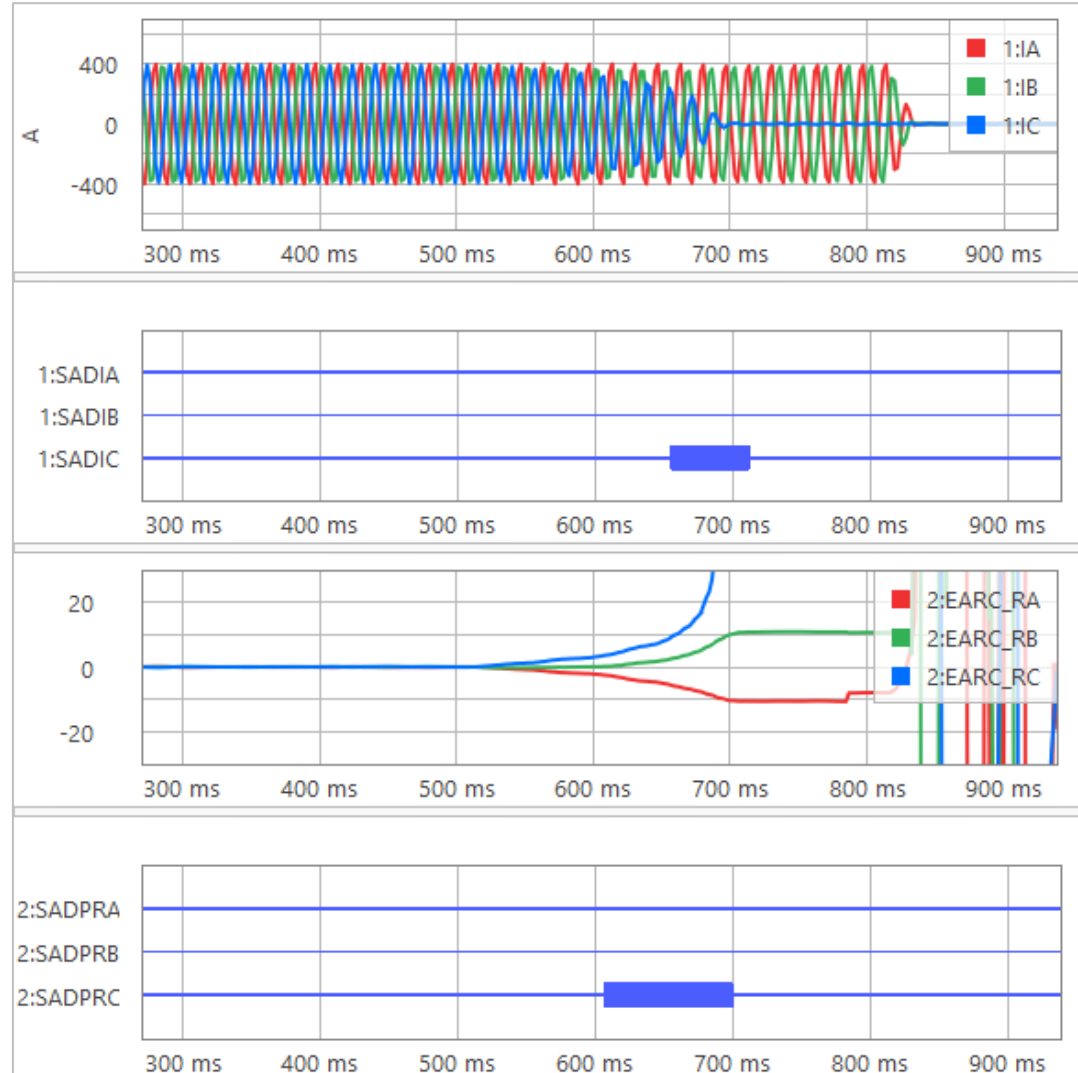
Loss-of-load detection



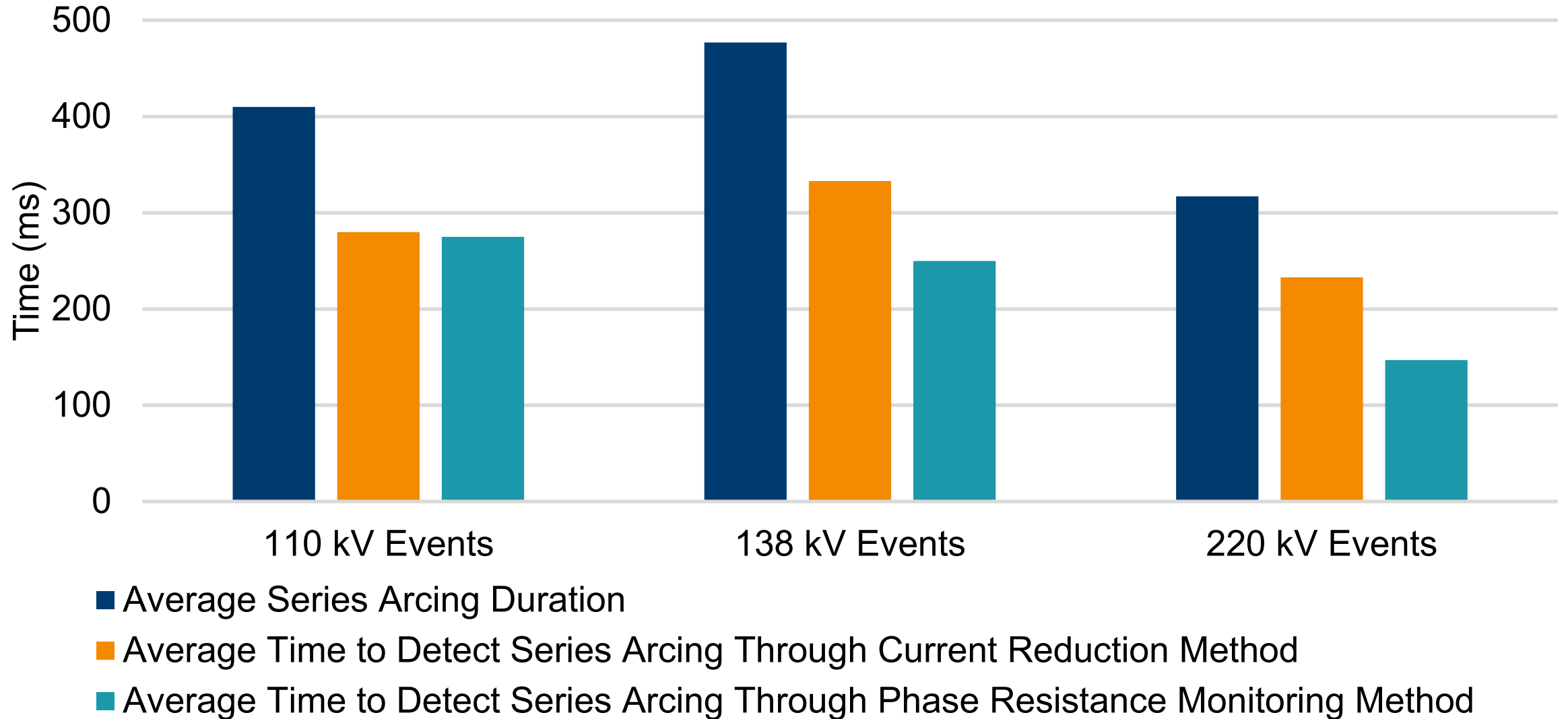
Detection of conductor breaks in tapped feeders



# Validating the proposed methods through field events



# Validating the proposed methods through field events



# Performance analysis of other methods

Event	Terminal	Voltage Level (kV)	$\Delta V_{PH}$ (pu)	$\Delta V_0$ (pu)	$\Delta V_2$ (pu)	$\Delta Z$ (pu)
1	Local	220	-0.005	< 0.026	< 0.019	6
	Remote		0.001			135
2	Local	138	-0.018			151
	Remote		0.006			139
3	Local	110	-0.032			23
	Remote		0.011			23
4	NA	220	0.003			9
5	NA	138	-0.019			14

# Conclusion

- Detection of broken conductors was successful by using the proposed single-ended methods
- The proposed methods can work for transmission, sub-transmission systems, tapped feeders, and distribution systems
- Field events have shown no significant change in voltage magnitudes before and after the conductor break
- Methods that rely on change in impedance may have less dependability for lines with significant charging current



**Questions?**