High Frequency Travelling Wave Fault Location Methods

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'Travelling Wave' is a temporary surge of current or voltage generated at the source of the fault and moves along either ends of the Transmission Line.

Used Fault Location Methods

Waveform Analysis

Old method used in non-digital time, where oscillograph was used as the fault locator

Impedance Calculation

Commonly used, cost effective but poor accuracy
Applicable only for normal AC power lines

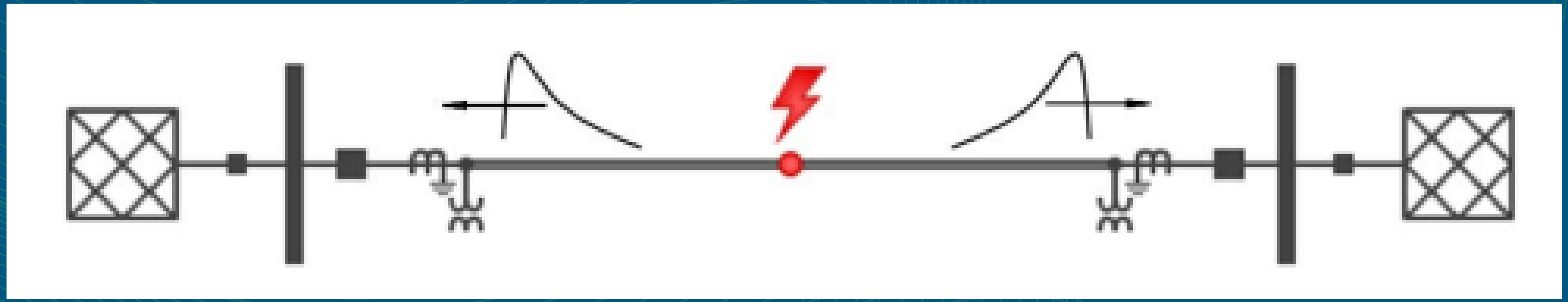
Travelling Wave Method

The most efficient solution
Excellent Accuracy
Can be applied for all kind of power lines

What is the Travelling Wave Fault Location?

The term “traveling wave fault location” refers to the method of locating a fault or disturbance on an overhead or underground cable that is used to transmit power across an electrical network.

When a fault does occur, it can be difficult to locate, particularly on long remote lines.



Why is the Travelling Wave Fault Location Important?

- A fault generally last a number of milliseconds
- It is then possible to calculate how much cable is in play and therefore how far it is to the fault location.
- However, this method is fraught with errors.
  - High impedance objects
  - Line parameters
  - Mutual coupling
  - Unstable fault arc
- A more accurate fault location method such as 'Traveling Waves ault Location' is necessary:
  - Reduce manpower
  - Reduce time searching
  - Reduce downtime

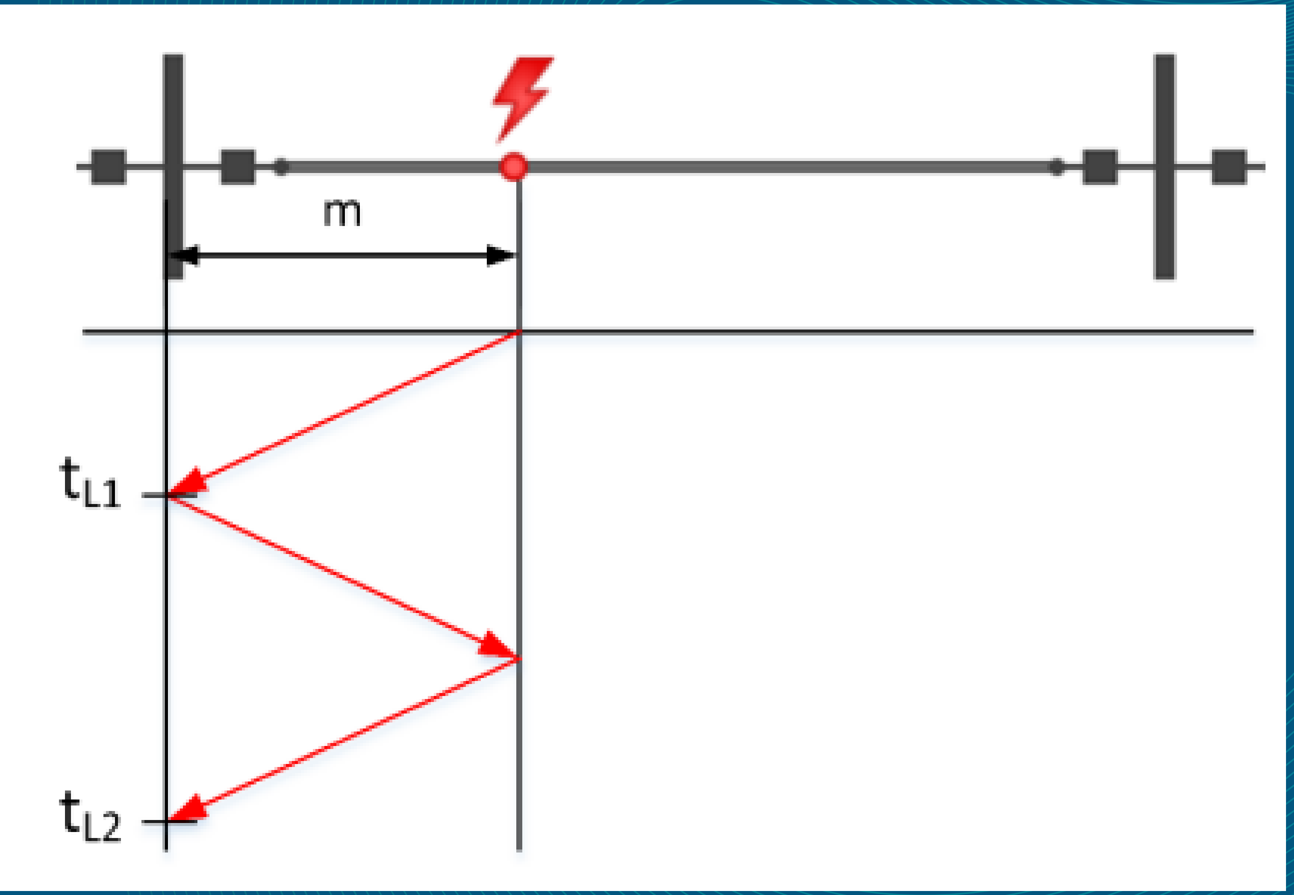
Single-Ended Method

Does not need information from the remote end of the line ➡ communications channel between the devices

The location is calculated based on the **arrival times of the first traveling wave** and the first wave reflected back

This simple formula can be used to calculate the fault location m:

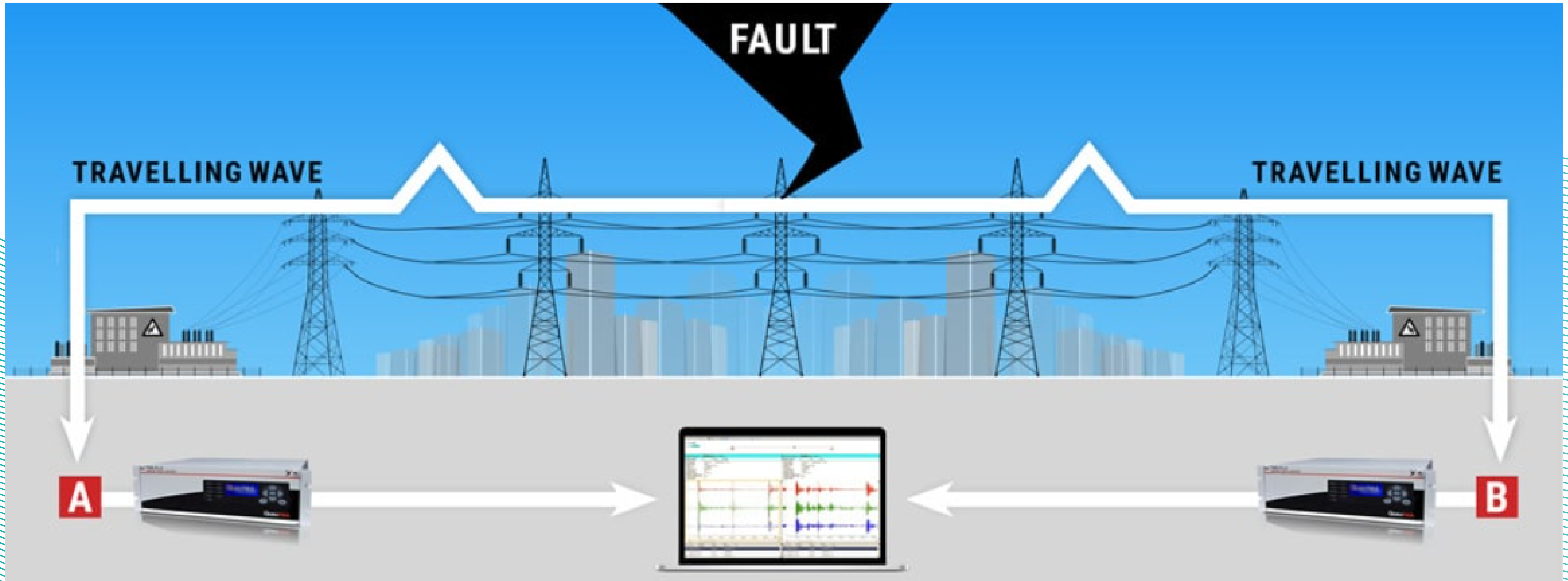
$$m = \left(\frac{t_{L2}-t_{L1}}{2}\right) \times v$$



- $tLL2$ is the arrival time of the first traveling wave
- $ttLL2$ the time stamp from the first reflected wave back from the fault
- and vv is the propagation velocity

Double-Ended Method

1. Time delay between communication channels need to be accounted for
2. The power arc at the fault site
3. TWS fault locators at the line ends tag the arrival time of the waves
4. Calculations to locate the fault



- The arrival times of the traveling waves on both ends of the line are compared and the fault location m is calculated according to the following formula:

$$m = \frac{1}{2}(l + (t_L - t_R)v)$$

→ Where l is the length of the line

→ tL and tR are the arrival times of the traveling wave at the local and remote end respectively

→ v is the propagation velocity

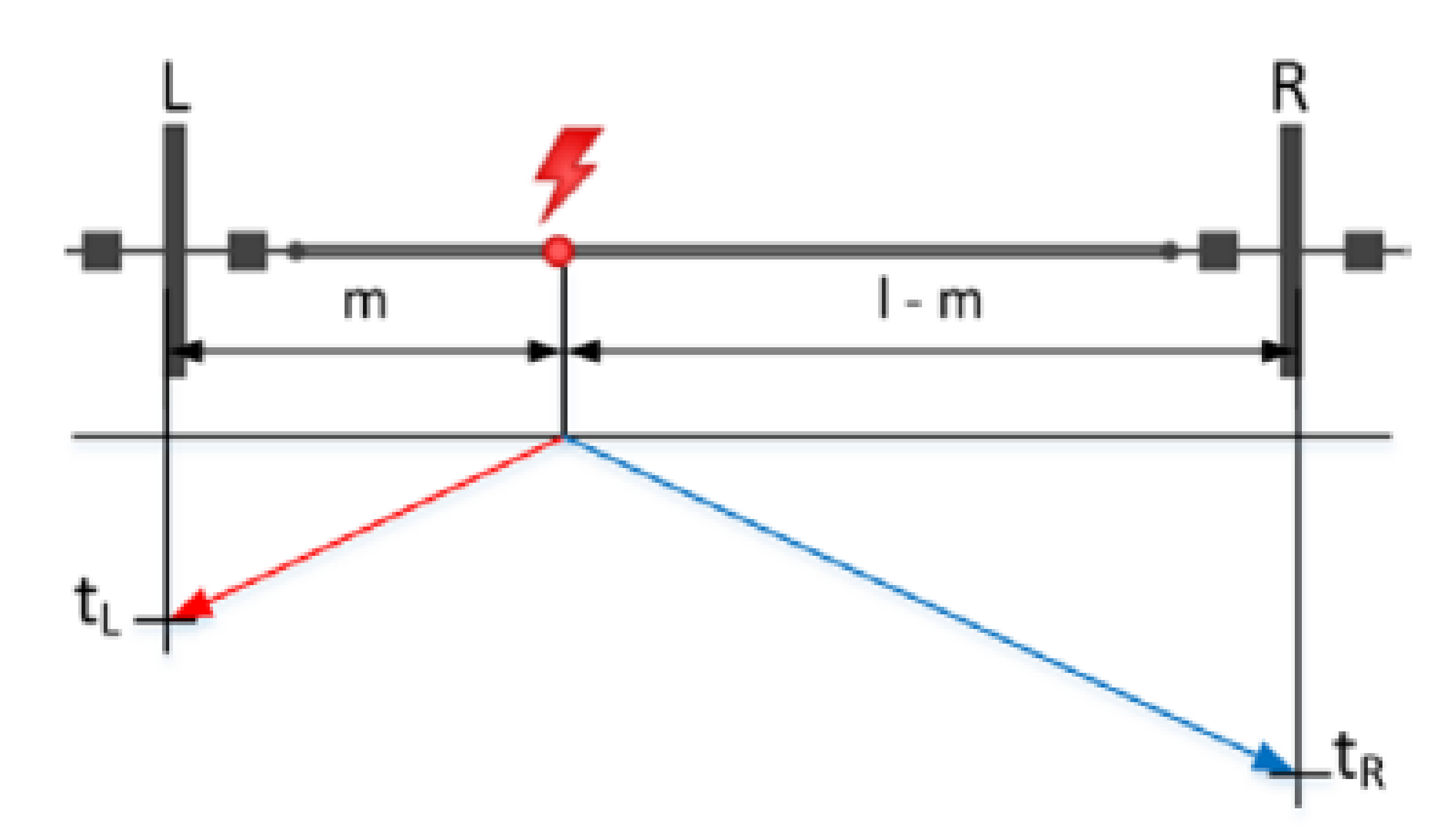


Figure 3: Two-ended fault location based on time difference of first arrival times

- The calculated location solely depends on the precise arrival time stamps of the detected traveling wave fronts and a correct length of the transmission line.

Simulations

MATLAB/SimuLink

Wavelet Transform

Clarke Transfo

$$DWT(k,n,m) = \frac{1}{\sqrt{a_0^m}} \sum_n x[n]\, \Psi \left(\frac{k - n b_0 a_0^m}{a_0^m} \right)$$

$$\begin{bmatrix} I_\alpha \\ I_\beta \\ I_0 \end{bmatrix} = \frac{2}{3} \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{bmatrix} \begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix}$$

Risk Assesment

Risk	Probabiity	Seriousness
Missing Deadline	5	10
Fatigue	3	4
Computer not working	3	9

Timeline

	Completed	Oct				Nov				Dec				Jan			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Planning	Yes		■	■													
Research	60%			■	■	■	■										
Proposal	70%				■												
Simulations	15%					■	■	■									
Final Presentation	0%								■	■	■	■					
Final Report	0%											■	■	■	■		

Budget

€ 2,700

Thank You