QUALITROL®

TWS-FL8 Beats Competitors

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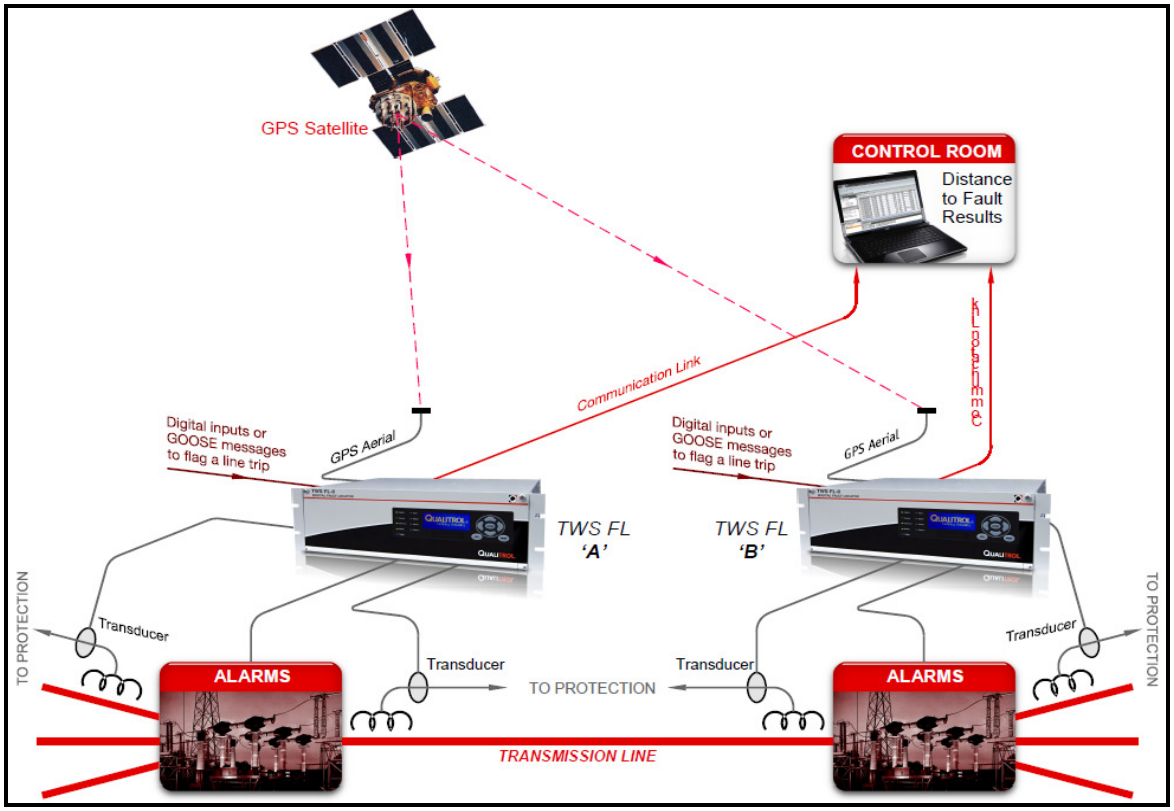
1. Introduction

In early spring 2012 four companies were invited to demonstrate their “travelling wave” fault location devices by an Asian utility. The demonstration would take the form of a test where the utility would induce 5 faults at different locations on a live 115kV transmission network. Each company would have 2 days to install their equipment and on the third day the faults would be induced. On that third day the four companies would be placed in a room with remote access to their devices. As each fault occurred they would be asked to communicate to their respective units and give the “distance to fault”. The live faults were performed on 13th of May 2012.

Qualitrols TWS-FL8 device consistently gave the most accurate results over the course of the 5 faults. The TWS-FL8 located three of the faults to within 45m. While the accuracy of the TWS-FL8 on the fourth fault was 300m it was still beating the competitors by a factor of two. On the 5th and final test (high resistance fault) Qualitrols TWS-FL8 was the only device to trigger and capture the fault. It located the fault to within 268m i.e. 0.3% of the line length.

This document gives more detail on the test performed along with the actual results from all 4 companies. Records, installation photos and master station screen grabs are taken from Qualitrol TWS-FL8 and iQ+ products.

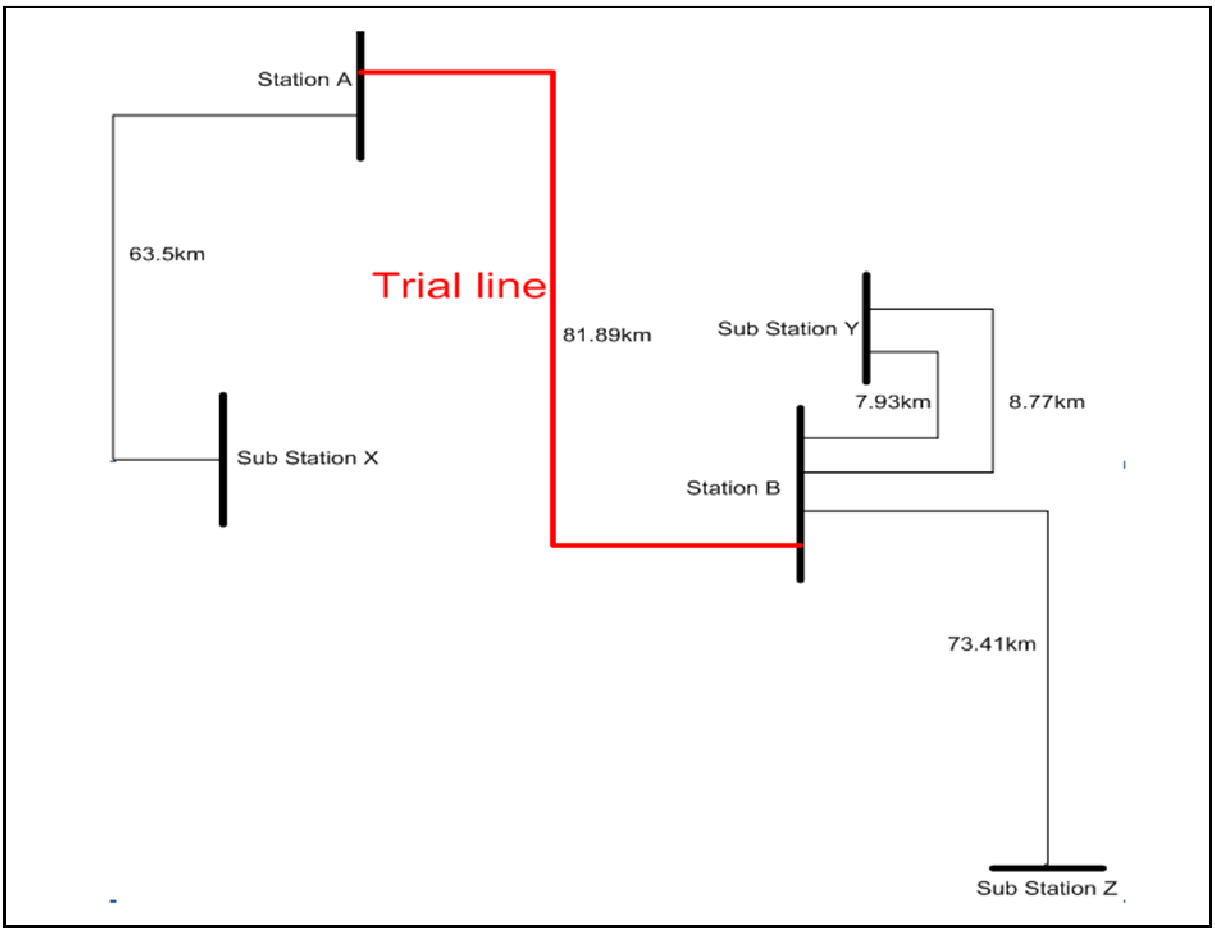
Figure 1 A typical double ended fault location setup.



2. Installation and the network.

The 5 faults were performed on a 115kV network. The single line diagram is shown below in figure 2. The substation names have been changed to respect the utilities request for anonymity. The faulted overhead line (shown in red) was reported to be 81.89km long. Each of the four participating companies placed fault location devices in substation “A” and substation “B”.

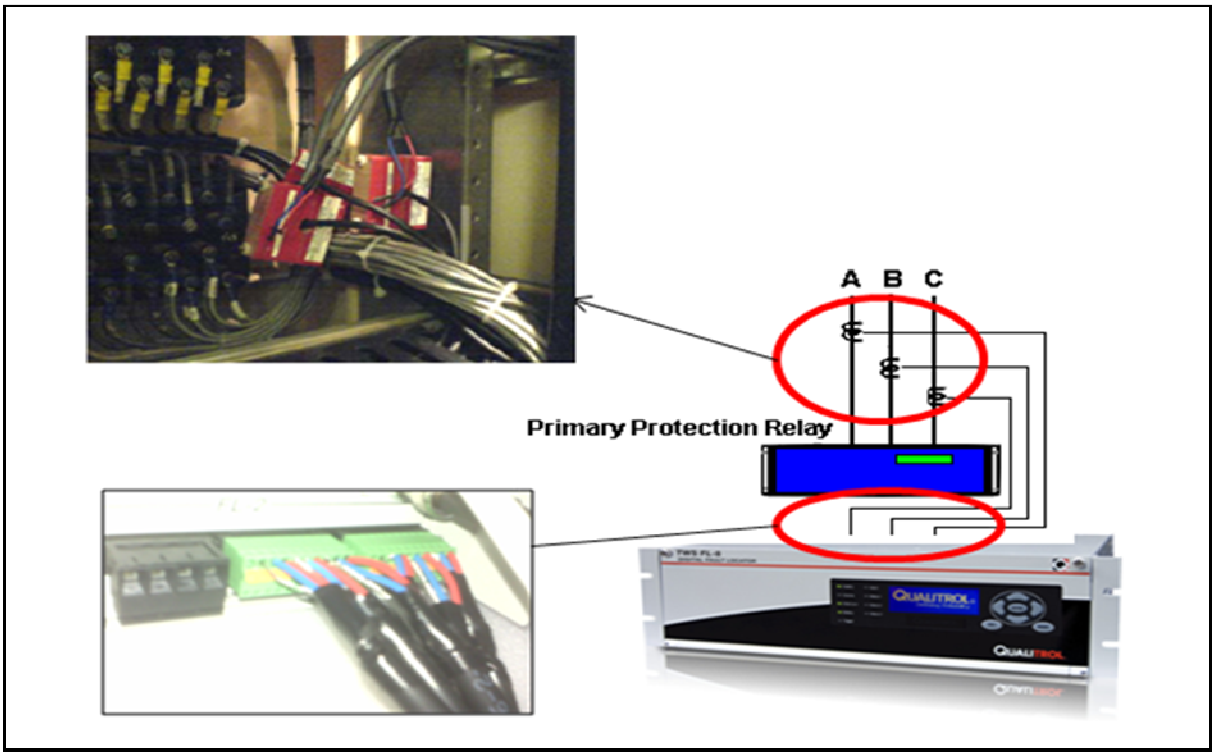
Figure 2 Single line diagram



As each fault was created on the 115kV circuit a high frequency travelling waves was produce. These waves spread out each direction along the transmission lines eventually reaching the substations at either end. The units placed at each end of the overhead line would capture and time tag the arrival of the high frequency travelling waves. The time difference between the time tags from each end of the line would be used along with the speed of the travelling wave to work out the distance to fault.

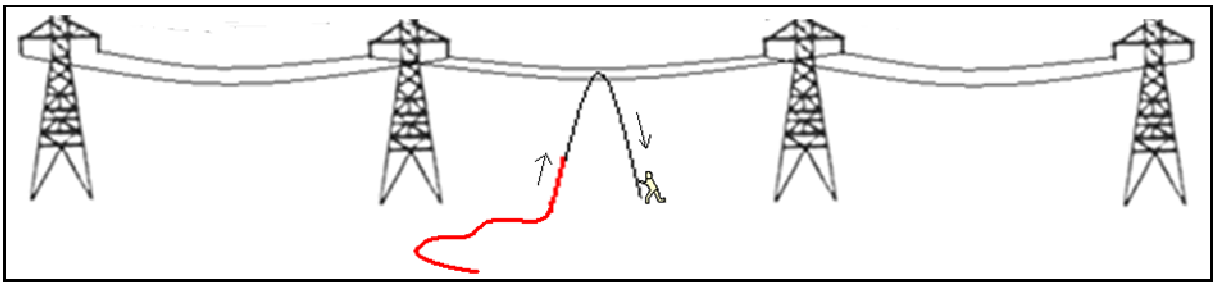
Figure 3 shows how the TWS-FL8 captured the travelling waves by placing red split core linear couplers over cables feeding the current signals to the protection relay. The output from these red linear couplers were fed back to the input of the TWS-FL8

Figure 3 TWS-FL8 installation



Faults were induced using a high impedance rope attached to a low impedance thread. The high impedance rope was looped over the cable(s) of the overhead line. A line patrol engineer then slowly pulled on this rope until the low impedance section touched the cable and produced an arc. See figure 4 below.

Figure 4



3. The Results

The first test took place at 8:31:33 in the morning. The results from the 4 companies and the actual distances to fault are shown in the table 1 below.

Table 1

Fault 1								
	Real DTF from end A 77.769Km			Real DTF from end B 4.165Km			Phase	
Company	Distance Km	error in Km	% error in result	Distance Km	error in Km	percentage error in result	Company phase	Actual phase
Company 1	77.6	0.169	0.21	4.2	-0.035	-0.83	A	A
Company 2	Fail	Fail	NA	Fail	Fail	NA		
Company 3	77.417	0.352	0.45	4.483	-0.318	-7.09	A	
Qualitrol Result	77.77	-0.001	0.00	4.12	0.045	1.09	A	

Qualitrols calculated distance to fault was to within 45 meters of the actual values quoted by the utility. Figure 5 on the following page shows the matched pair taken from Qualitrols iQ+ software. Two of the other competitors give distances to fault as far out as 169m and 352m. The fourth competitor fails to capture signals due to equipment malfunction. They drop out of the testing.

The line length had originally been quoted as 81.89km however following a reclose the line length was calibrated using single ended analysis. Figure 6 shows a screen grab again taken from Qualitrols iQ+ master station software. The time difference between the original pulse caused by the reclose and the reflected pulse received back from the far end of the line were used to calculate the real line length. In this case the real line length was measured as 81.93km. This was later confirmed by the utility using type A travelling wave detection.

Figure 5 Matched pair for first fault.

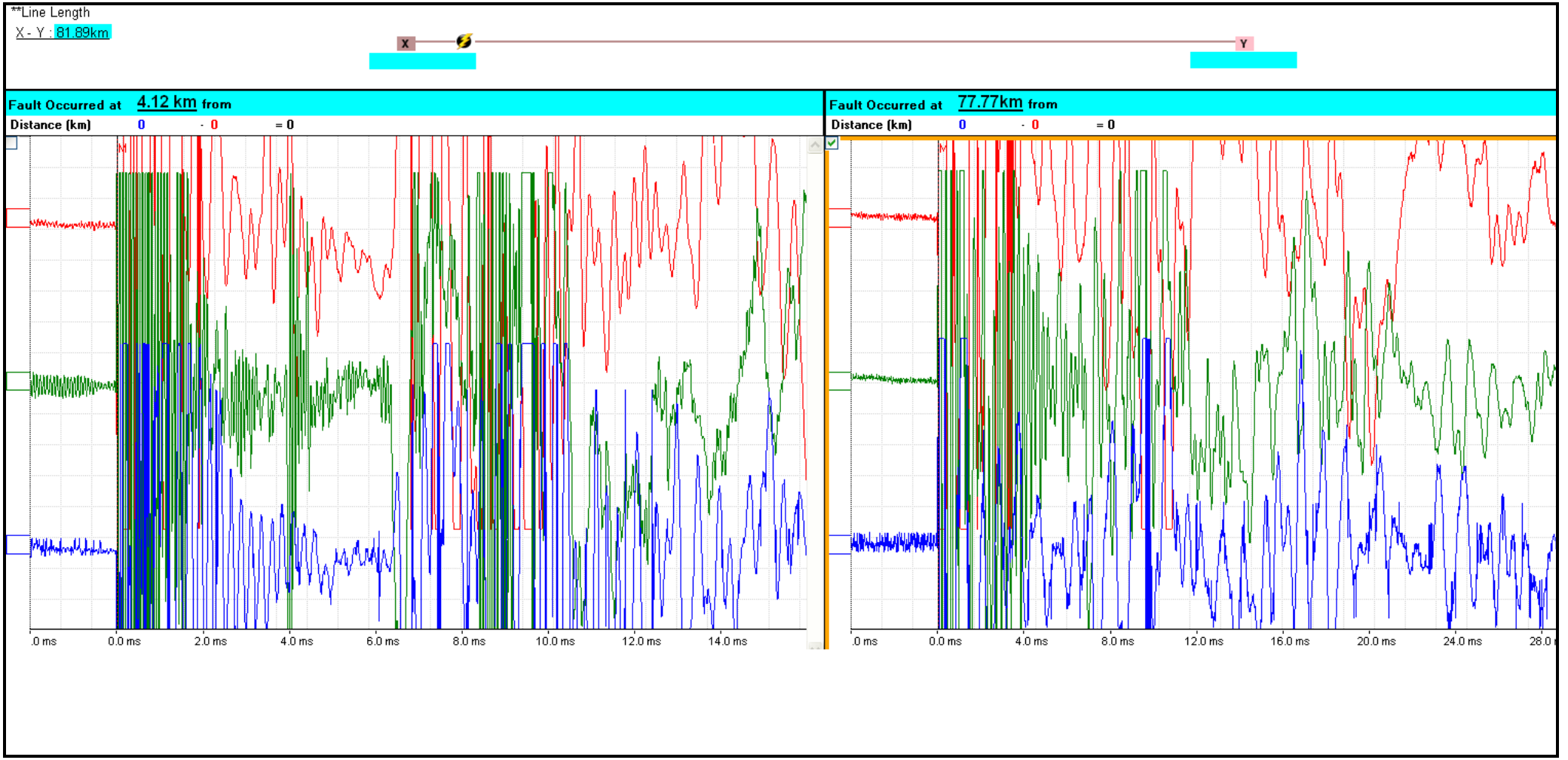
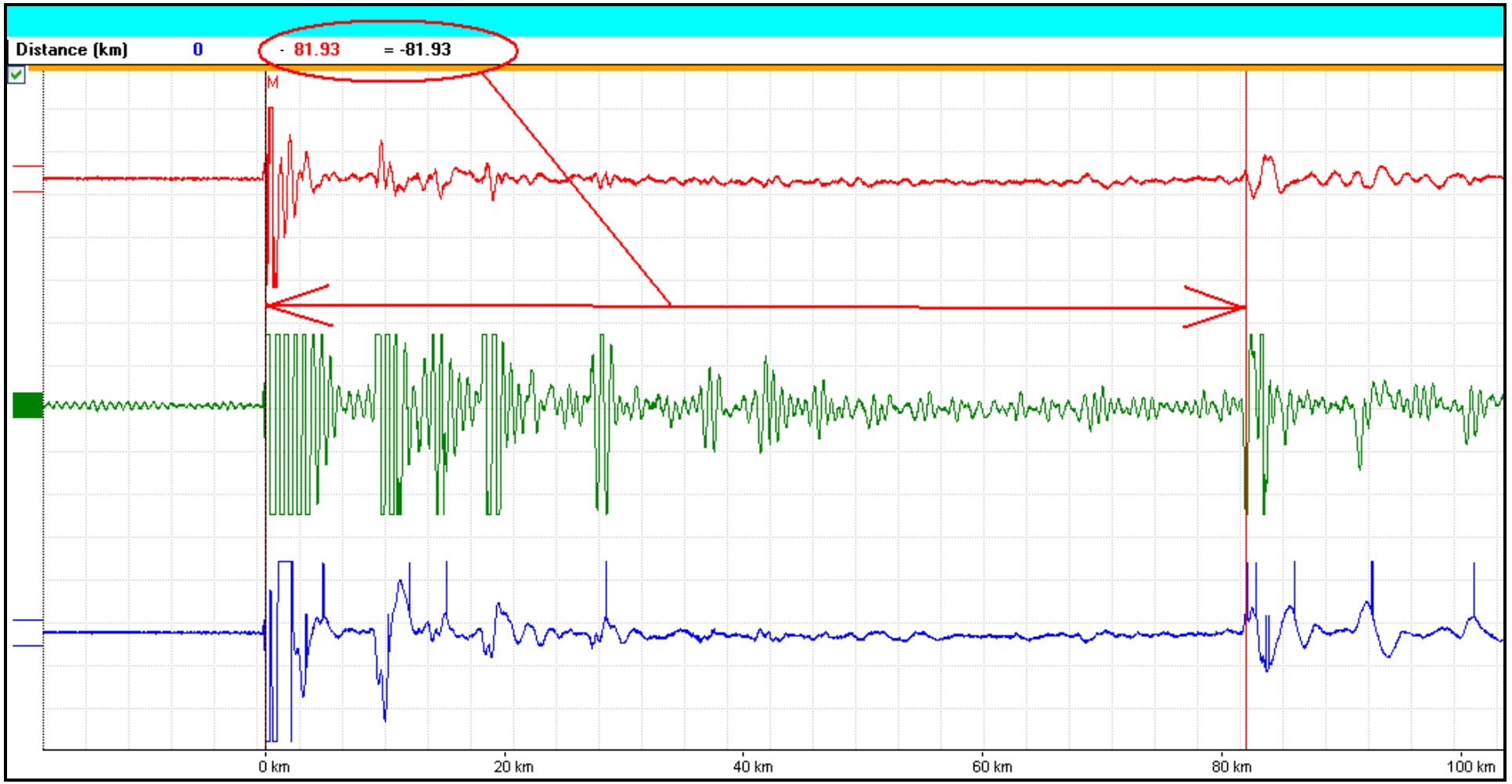


Figure 6 Line length calibration using single ended analysis.



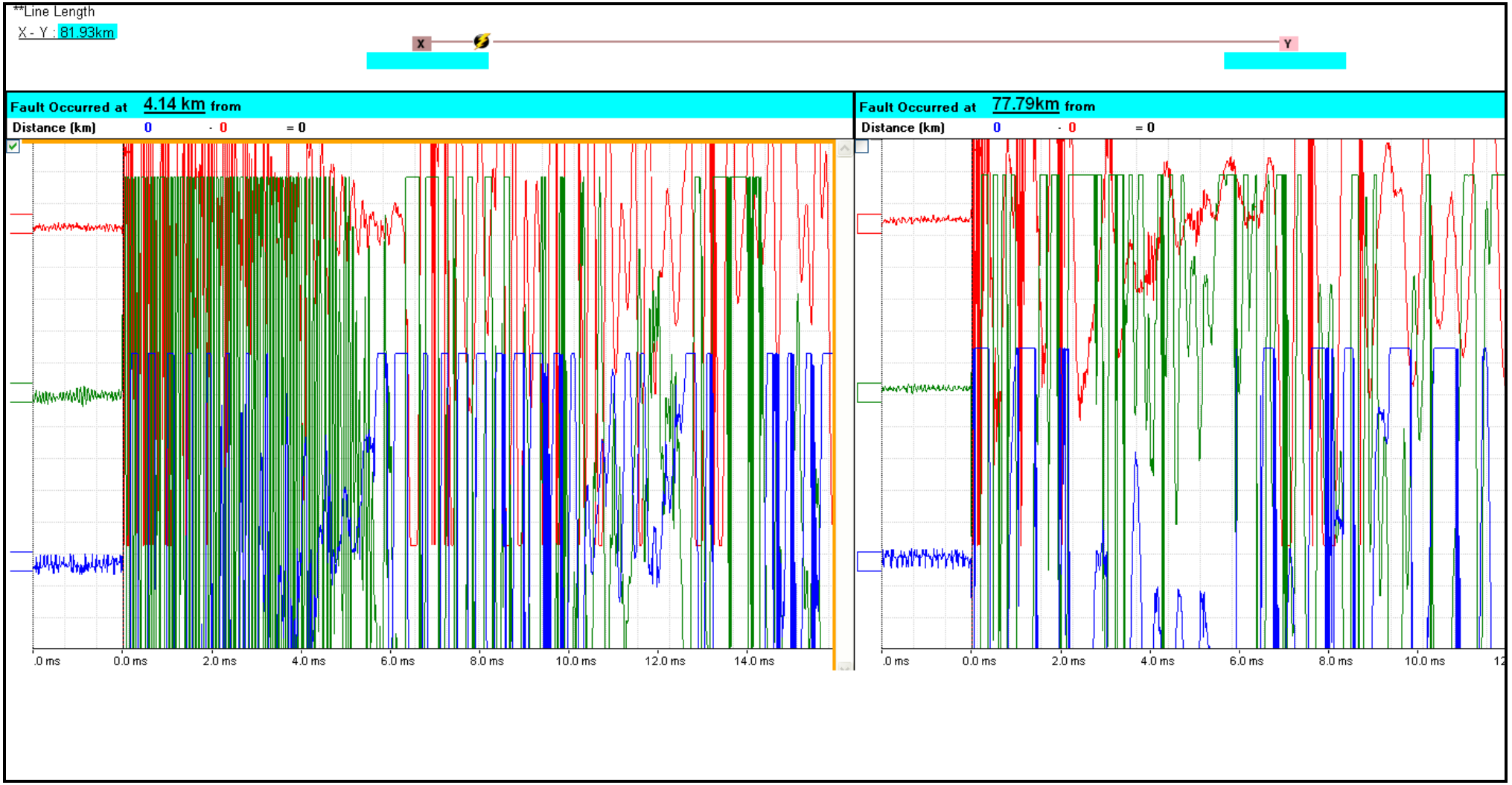
The second test took place at 9:18:11am. The results from the 4 companies and the actual distances to fault are shown in the table 2 below.

Table 2

Fault 2								
	Real DTF from end A 77.769Km			Real DTF from end B 4.165Km			Phase	
Company	Distance Km	error in Km	% error in result	Distance Km	error in Km	percentage error in result	Company phase	Actual phase
Company 1	77.3	0.469	0.60	4.5	-0.335	-7.44	B+C	B+C
Company 2	Fail	Fail	NA	Fail	Fail	NA		
Company 3	78.167	-0.398	-0.50	3.767	0.398	10.56	B+C	
Qualitrol Result	77.79	-0.021	-0.02	4.14	0.025	0.60	B+C	

Again Qualitrols TWS-FL8 unit was the most accurate give a distance to fault that was to within 25m of the actual distance quoted by the utility. Other competitors were out by 496m and 398m respectively. Figure 7 on the following page shows the matched pair taken from Qualitrols iQ+ software.

Figure 7 Matched pair for second fault.



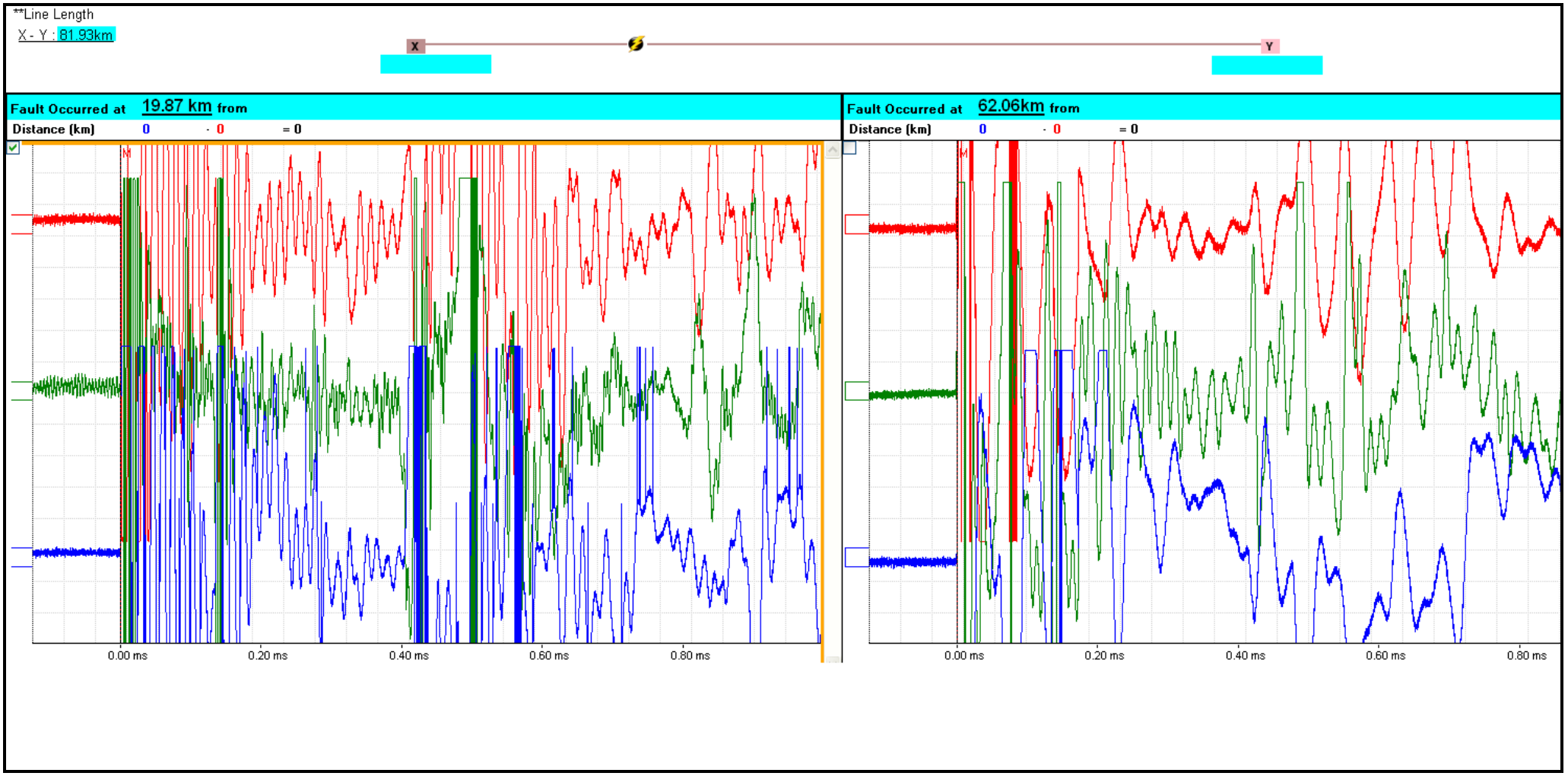
The third test took place at 10:34:06am. The results from the 4 companies and the actual distances to fault are shown in the table 3 below.

Table 3

Fault 3								
	Real DTF from end A 62.35Km			Real DTF from end B 19.584Km			Phase	
Company	Distance Km	error in Km	% error in result	Distance Km	error in Km	percentage error in result	Customers phase	Actual phase
Company 1	61.7	0.65	1.05	20.1	-0.516	-2.56	C	C
Company 2	Fail	Fail	NA	Fail	Fail	NA		
Company 3	61.567	0.783	1.27	20.367	-0.783	-3.84	C	
Qualitrol Result	62.05	0.3	0.48	19.88	-0.296	-1.48	C	

Qualitrols TWS-FL8 continues to outperform the competition. The FL8 gives the distance to fault to within 300m of the actual fault. This distance is two times more accurate than the other devices.

Figure 8 Matched pair for third fault.



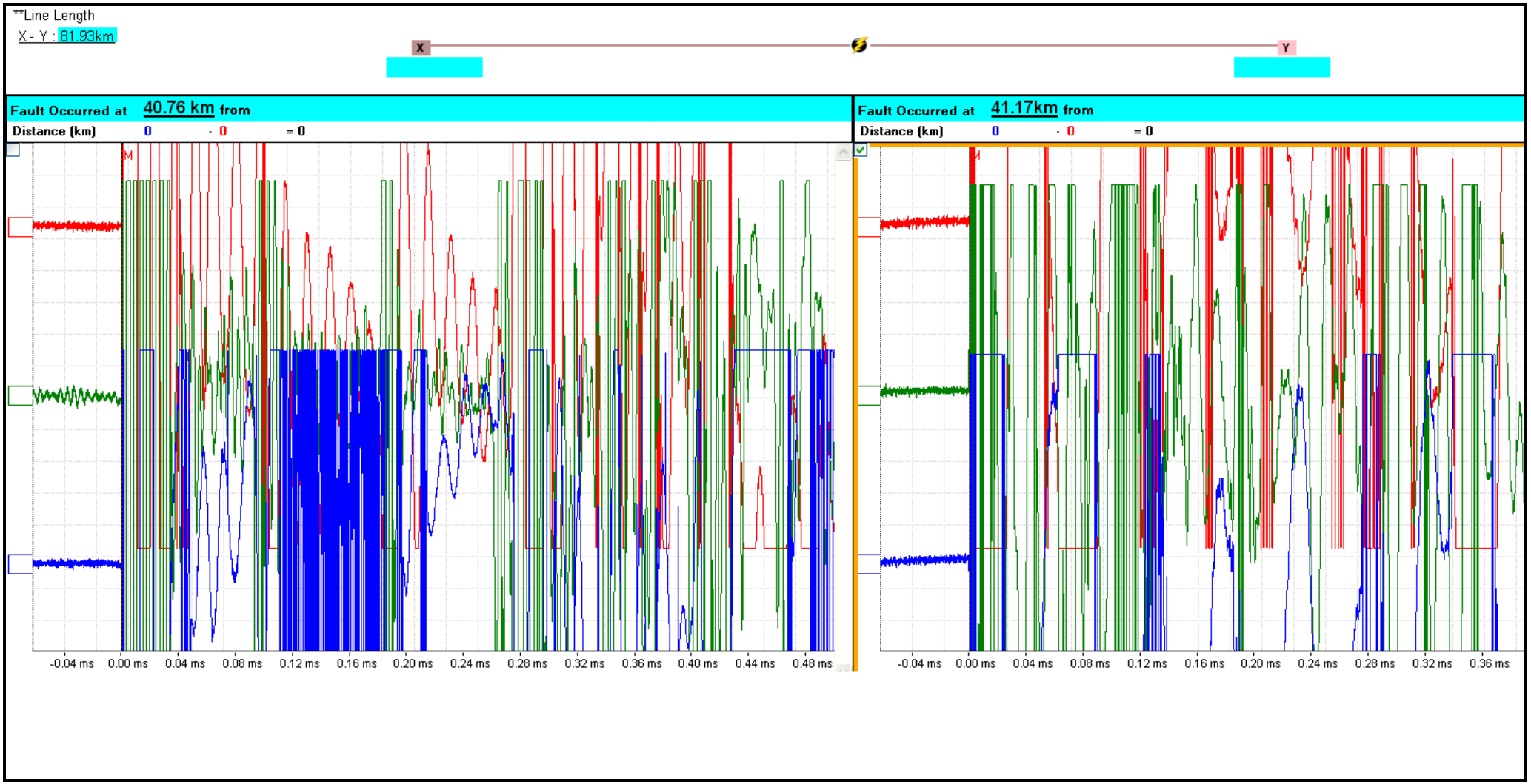
The fourth test took place at 10.59.11am. The results from the 4 companies and the actual distances to fault are shown in the table 4 below.

Table 4

Fault 4								
	Real DTF from end A 41.199Km			Real DTF from end B 40.735Km			Phase	
Company	Distance Km	error in Km	% error in result	Distance Km	error in Km	percentage error in result	Customers phase	Actual phase
Company 1	41.2	-0.001	-0.00	40.6	0.135	0.33	C+A	C+A
Company 2	Fail	Fail	NA	Fail	Fail	NA		
Company 3	42.704	-1.505	-3.52	39.23	1.505	3.83	C+A	
Qualitrol Result	41.17	0.029	0.07	40.76	-0.025	-0.06	C+A	

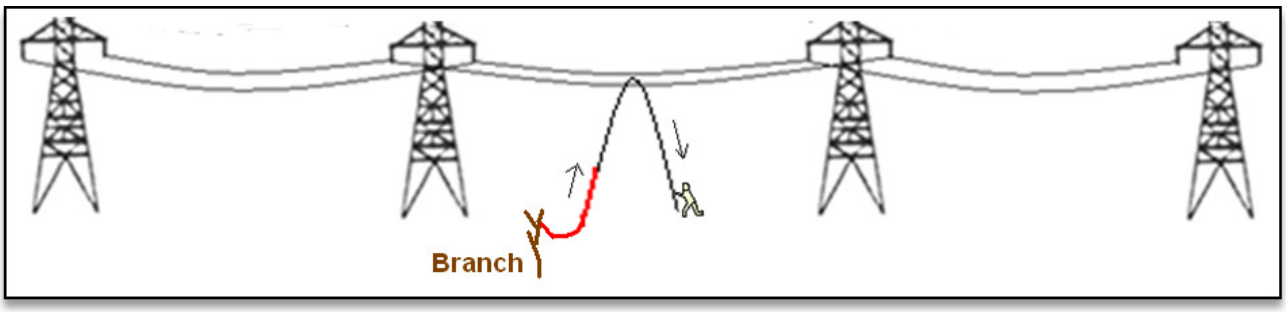
Qualitrols TWS-FL8 places the fault at 41.17km from one end of the line and 40.76km from the other. These distances are 29m and 25m away from the actual fault respectively. Once again the TWS-FL8 is the most accurate device. The competitor's quote distance to fault as far away as 135m and 1505m respectively.

Figure 9 Matched pair for fourth fault.



The fifth and final test was slightly different than the rest. It was an attempt to simulate a high resistance fault. The fault was induced using the same high impedance rope attached to a low impedance thread. However, this time rather than have the thread directly grounded to earth it was tied to a tree branch and the tree branch was pushed into the ground. See figure xxx below.

Figure xxx



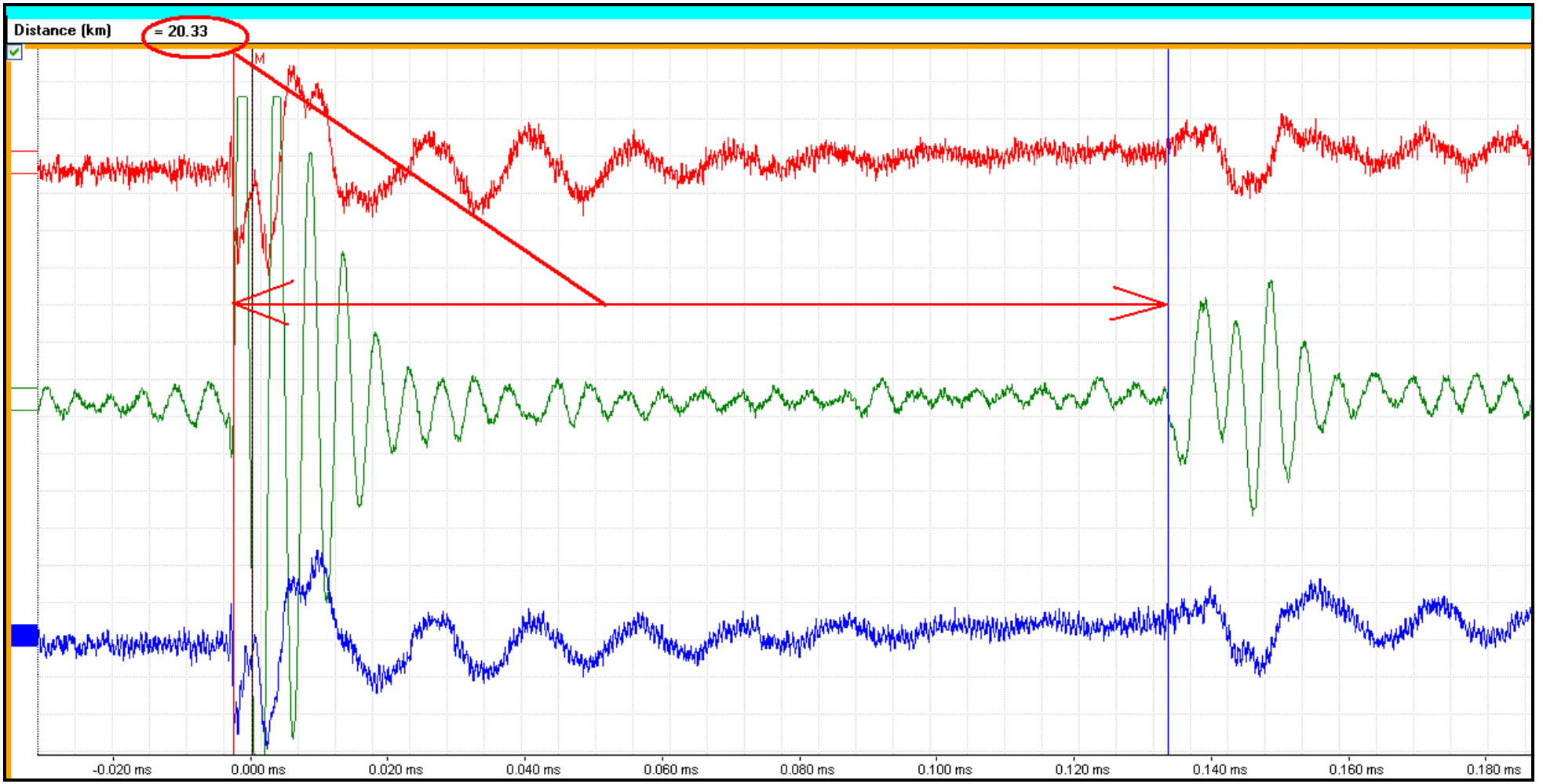
The rope was again looped over the cable(s) of the overhead line and a line patrol engineer slowly pulled on this rope until the low impedance section touched the cable and produced an arc. During this test the line being monitored did not trip. There was a lot of arcing but the branch simply burned right through with no flashover. With this information in mind the utility did not expect any of the units to trigger on this test. The results for test number five are shown in table 5 below.

Table 5

Fault 5 (High resistance fault)								
	Real DTF from end A 20.598Km			Real DTF from end B 61.336Km			Phase	
Company	Distance Km	error in Km	% error in result	Distance Km	error in Km	percentage error in result	Customers phase	Actual phase
Company 1	No trigger			No trigger				B
Company 2	Fail	Fail	NA	Fail	Fail	NA		
Company 3	No trigger			No trigger				
Qualitrol Result	20.33	0.268	1.31	No trigger			B	

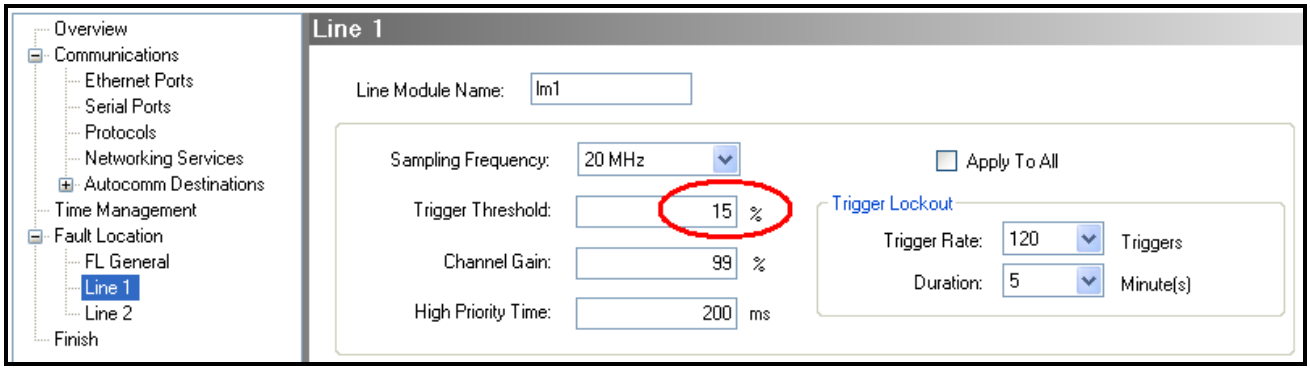
Qualitrols TWS-FL8 unit was the only device to trigger on this test. All other devices failed to capture any signal. While the FL8 did not trigger on both ends of the line it did capture the signal on one end. Using single ended analysis the distance to fault was given to within 268m of the actual fault distance. Figure 10 on the next page shows the record used for single ended analysis.

Figure 10 single ended analysis of fifth and final fault.



One of the flexible settings on the TWS-FL8 configuration is its trigger thresholds. For all the testing the TWS-FL8 trigger threshold had been set to 15% of the full scale deflection. See figure 11.

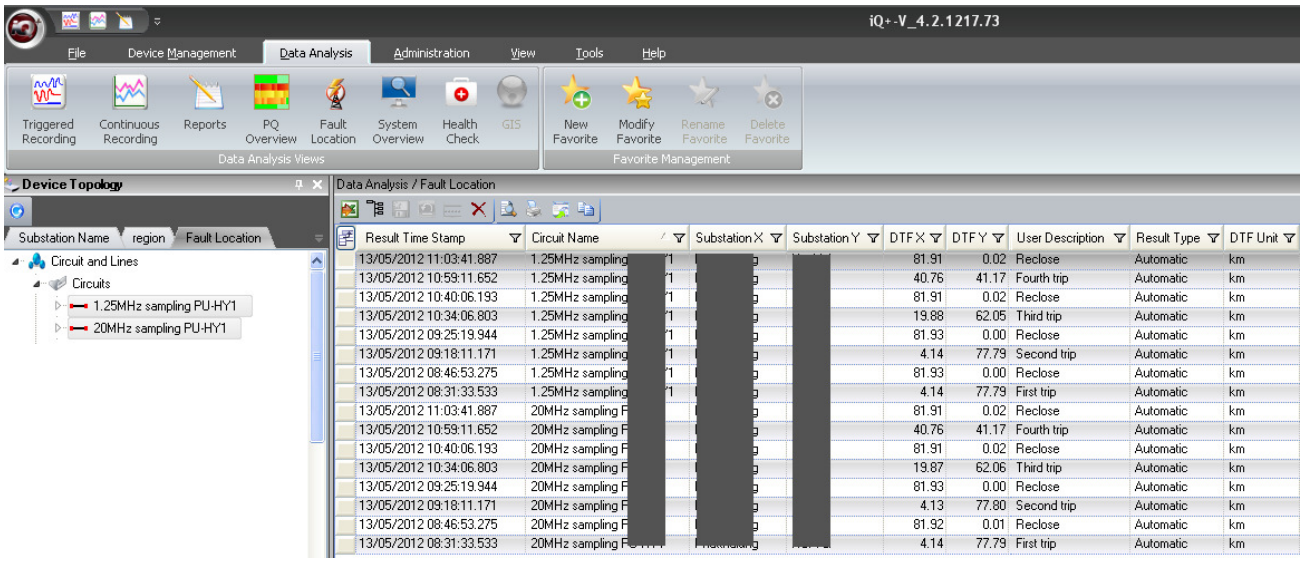
Figure 11 Trigger Threshold



This value could have been reduced to a lower value that would have allowed the TWS-FL8 units to trigger on both ends during test number 5. The test was not repeated at this lower threshold because one of the transmission line insulators had cracked during the previous fault.

For a full list of all TWS-FL8 results take from Qualitrols iQ+ master station software see figure 12 below. Note the unit was set to capture the travelling waves at 1.25Mhz and 20Mhz.

Figure 12 iQ+ screengrab showing fault location results.



4. Conclusion.

Travelling wave fault location is a very accurate method of locating faults on an overhead transmission line. Qualitrol has been supplying travelling wave fault location devices since 1992. In this time it has sold over 1500 fault location devices to 70 different utilities in over 30 countries around the world. It has been the leader in fault location devices for over 2 decades. The new TWS-FL8 platform (its 7th generation device) continues to prove that Qualitrol is best in class when it comes to accurate, fast and simple fault location devices.