Localization of fault No. 9

Pilot operation of Vdip system: 10/2020 – 12/2022

Author: David Topolanek

Contact: topolanek@vut.cz

Content

Analysis of fault record No. 9 – short-circuit L1-L2

The fault record No. 9 was ignited by two phase short-circuit L1-L2 and recorded by the feeder protection (RTU) on 2021-06-29 17:45:36.818.

Based on the feeder protection (FP) trigger, all 17 fault records were downloaded from DMUs (NSVMs). The fault location was found approximately 32 km from the substation and this fault record was used for earth fault localization two times (2 synchronization segments were available, see Fig 8).

Analyses of feeder protection record

In the first stage of the localization process, the fault record was downloaded from the feeder protection. The waveforms of the RMS values of phase voltages and currents recorded by the FP during the given fault are shown in Fig 1 and Fig 2.

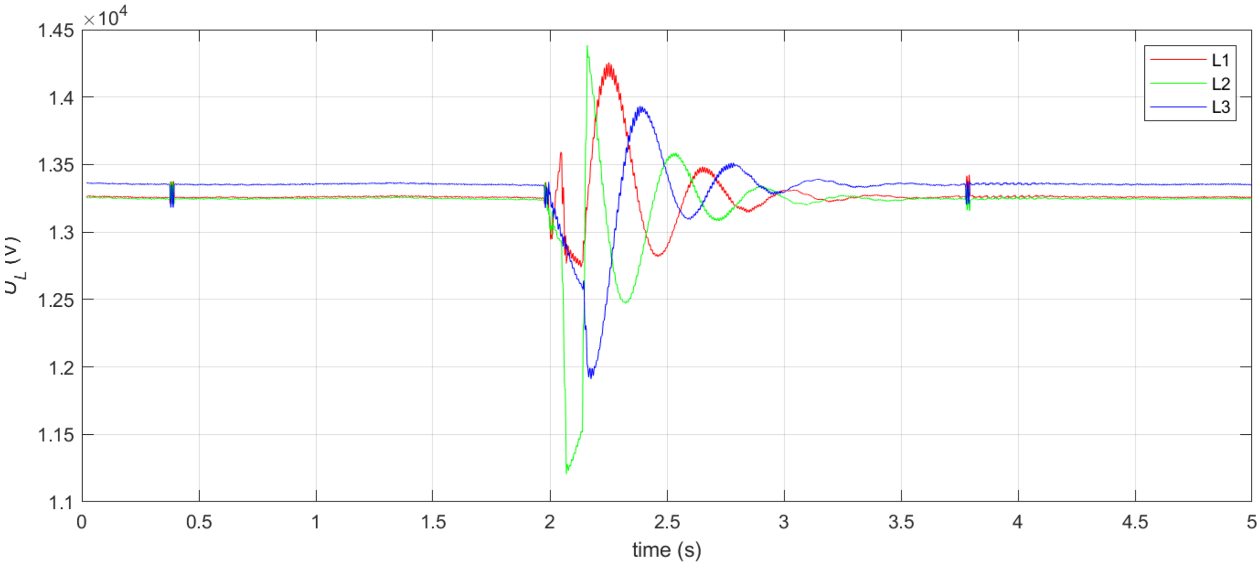

Fig. 1: RMS value of phase voltages recorded by feeder protection during fault No. 9

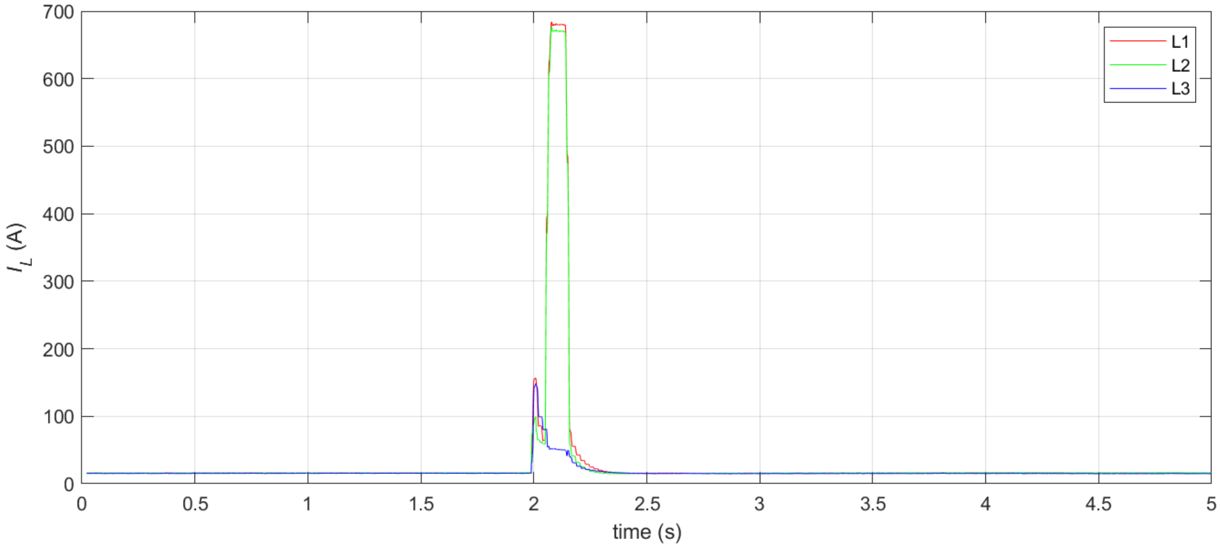

Fig. 2: RMS value of phase currents recorded by feeder protection during fault No. 9

The waveforms of zero sequence current and voltage, which reflect the behaviour of recorded earth fault, is depicted in Fig. 3. However, for the purpose of unsymmetrical faults localization using the Vdip system, the waveforms of the negative sequence voltage and current, shown in Fig. 4, are essential.

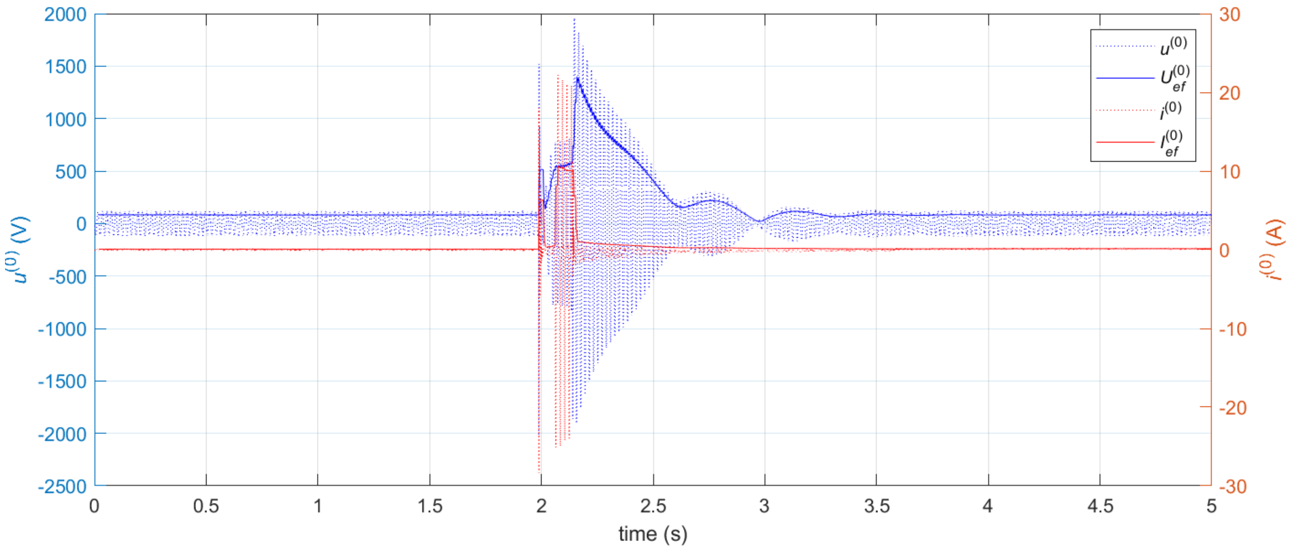

Fig.3: Zero sequence currents and voltages recorded by feeder protection during fault No. 9

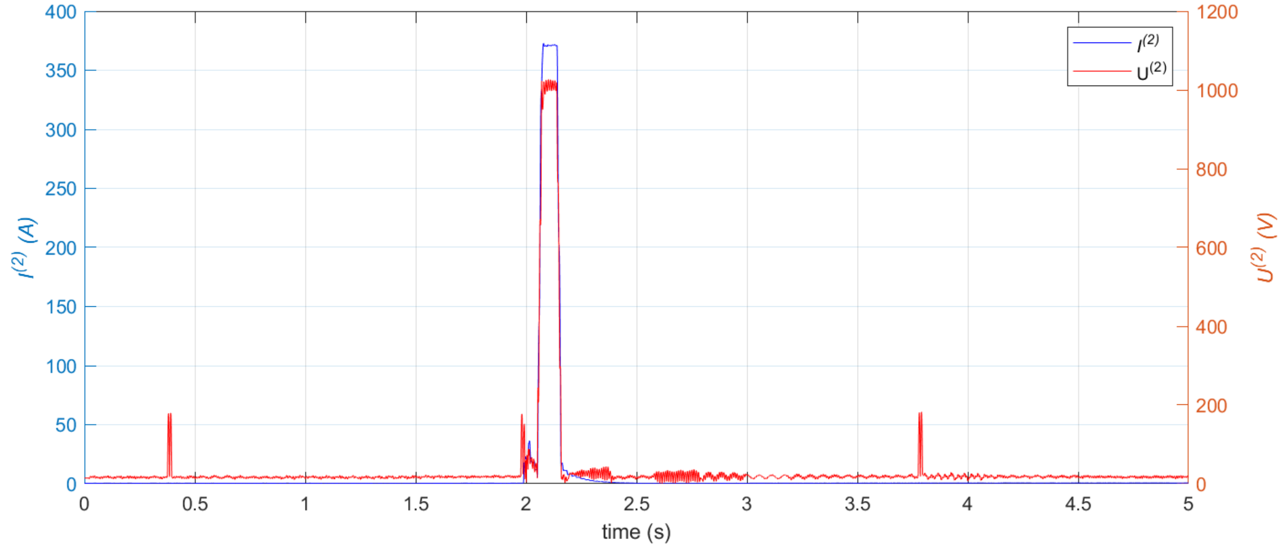

Fig. 4: Negative sequence current and voltage magnitudes recorded by feeder protection during fault No. 9

Negative sequence voltage and current changes of feeder protection calculated according to procedure described in [1] are shown in Fig. 5. These waveforms are crucial for identification the synchronization segments and subtraction of the maximum change of the negative sequence current for the localization algorithm.

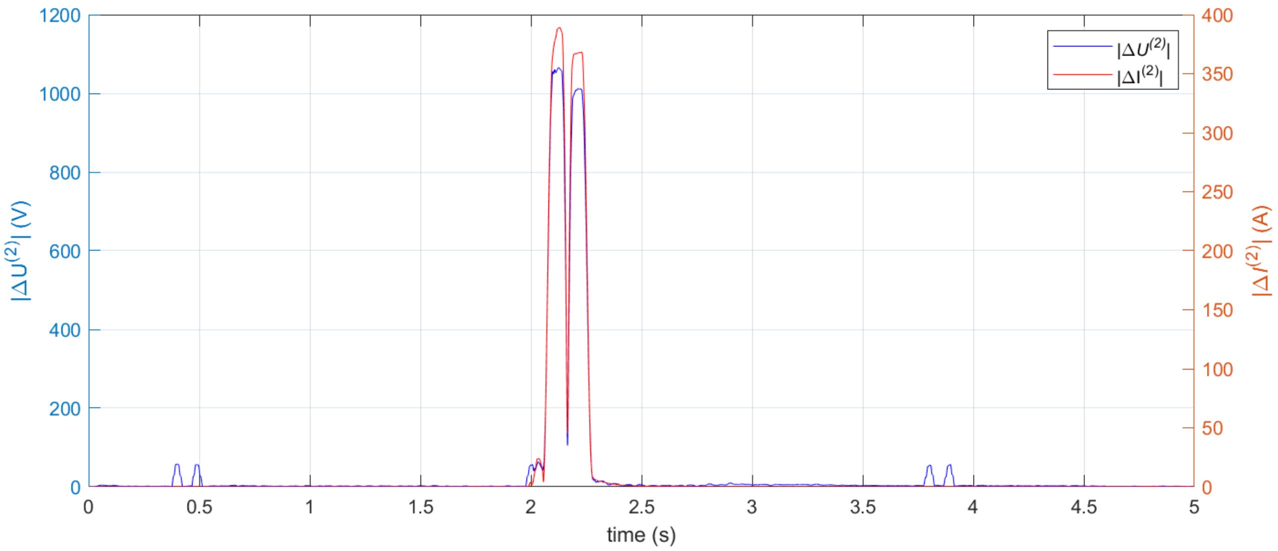

Fig. 5: Change in negative sequence current and voltage recorded by feeder protection (NSCM) during fault No. 9

Analyses of DMUs fault records

Based on the time of fault occurrence indicated by the feeder protection, fault records were downloaded from the relevant and available DMUs (NSVMs). RMS waveforms of phase voltage values are shown in Fig. 6.

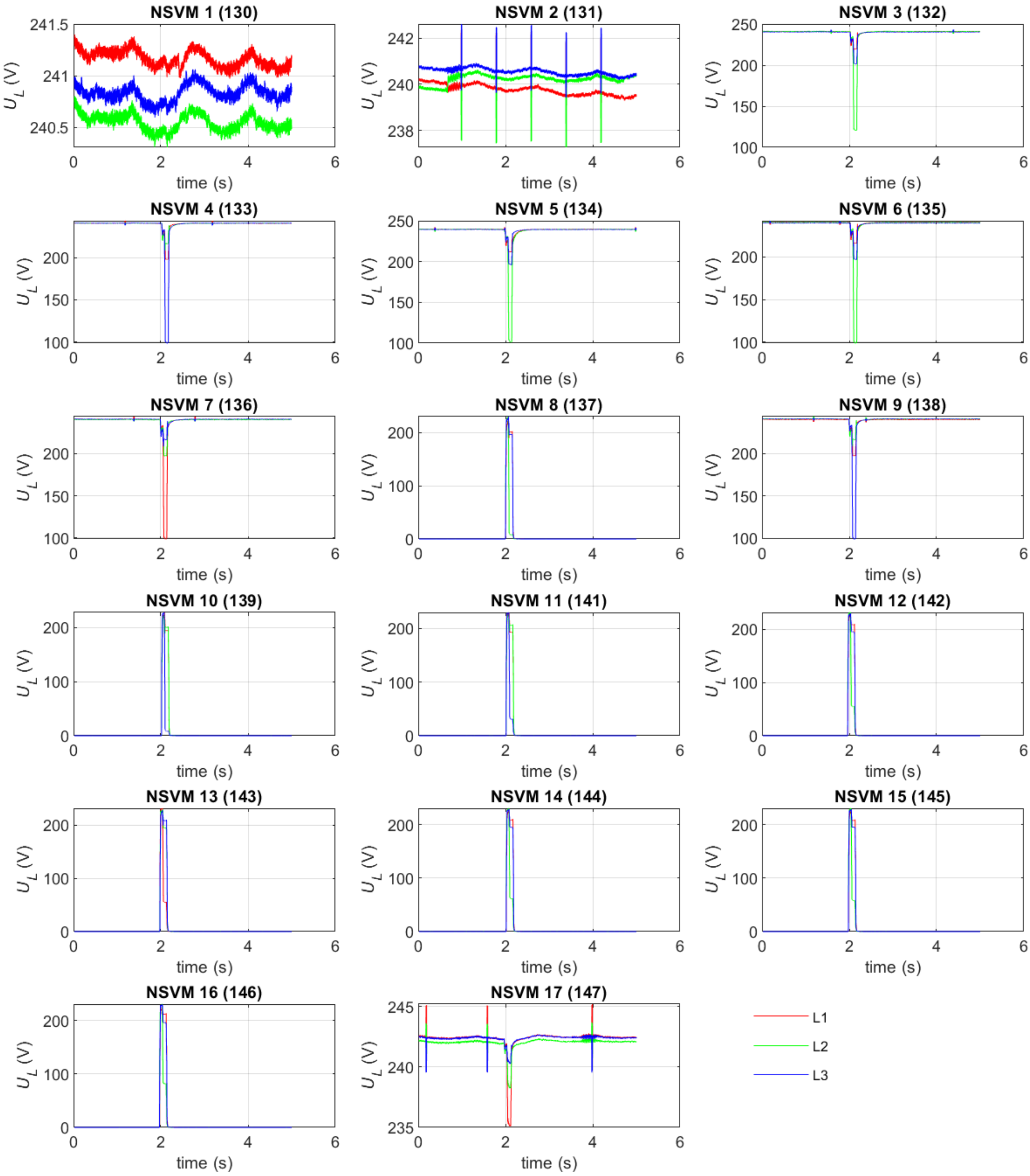

Fig. 6: RMS value of phase voltages recorded by DMUs during fault No. 9

After downloading the individual fault records from the DMUs, the calculation of the negative sequence voltage change is performed, similarly to the feeder protection. Synchronized waveforms of the negative sequence voltage changes of the individual NSVM (DMU) and the negative sequence current change of the NSCM (feeder protection) are shown together in Fig. 7.

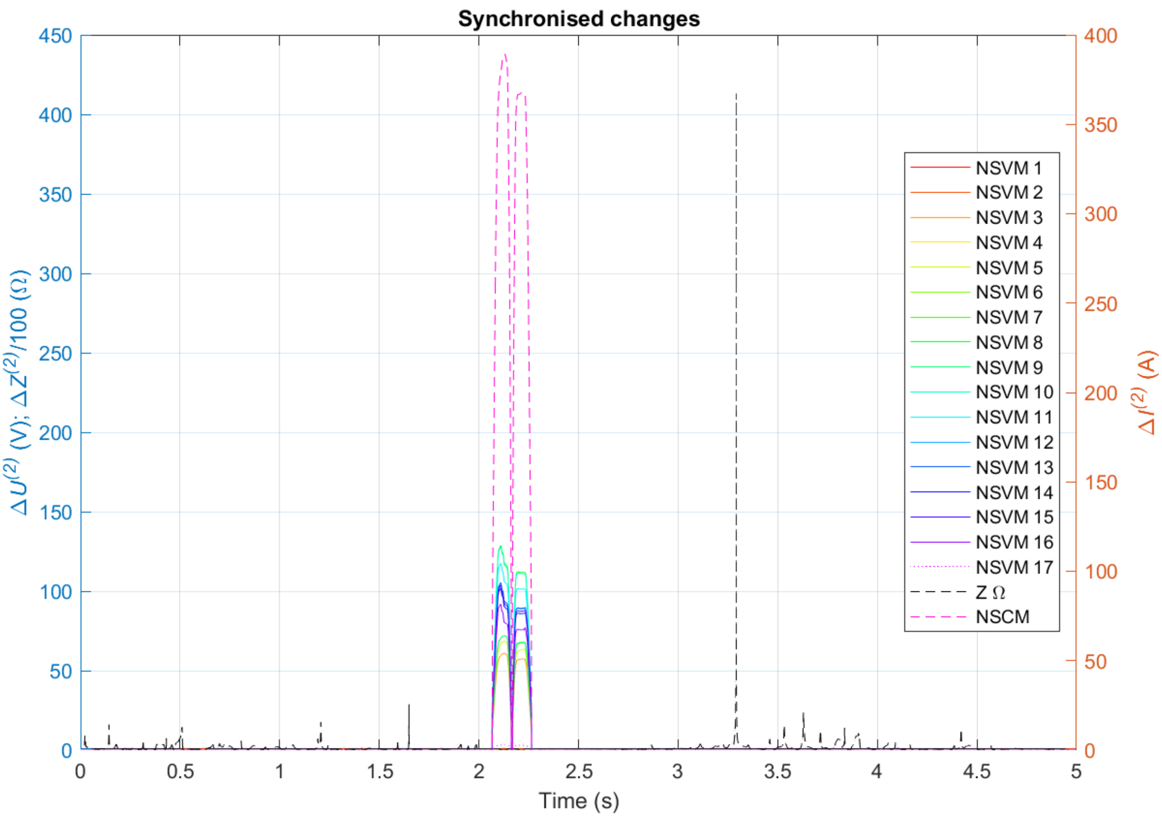

Fig. 7: Negative sequence current and voltage changes of NSCM and NSVM recorded during fault No. 9

In the next step, the Vdip system selects the synchronization segments from which the maximum in the negative sequence changes of voltage or current are read. These changes are then input to the localization algorithm described in [1]. One localization process can be run for each synchronization segment, which results in fault location determination. From the records depicted in Fig. 7 of fault No. 9, two synchronization segments were selected and are shown in Fig. 8.

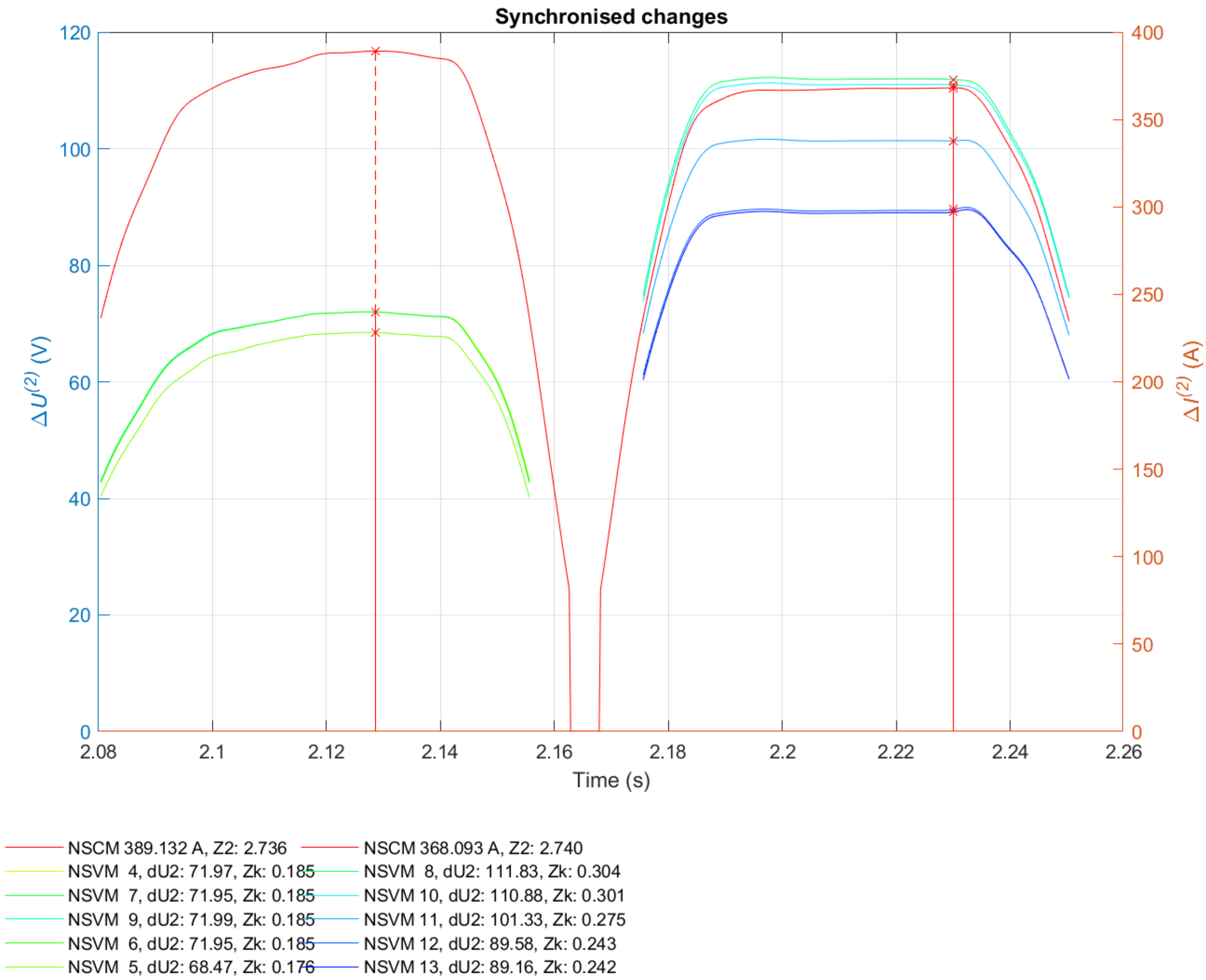

Fig. 8: Negative sequence current and voltage changes for individual synchronization pulses of fault No. 9

Vdip localization result

The bottom of Fig. 8 shows the data sets entering the Vdip localization algorithm, the results of which are shown in Fig. 9 (two data sets = two fault locations). The red cross indicates the location that is considered the most likely fault location (the result of the Vdip localization), the green crosses show the alternative fault locations (the results of the calculation of the remaining two segments), and the purple star shows the location where the fault was found by the DSO. In this case, the localization error of the Vdip method is about 0.7 km, the error of alternative segments is over 5 km (negative voltage change of crucial DMU was deformed). The distance of the fault is 32,1 km from the primary (supply) substation. Table 1 summarises the results of the localization based on fault record No. 9.

Tab. 1: Result of localization of fault No. 9

No.	Date	Fault Description		Real Fault Location	DMU records	Segments		Lokalization		Note
		Type	Characteristic			No.	Seg. Error (km)	Loc. Error (km)	Fault Distance (km)	
9	**2021-06-29 17:45:36.818**	**SC**	**SC L1-L2**	Yes	17	2	**0,7; >5**	0,7	32,1	Successful localization

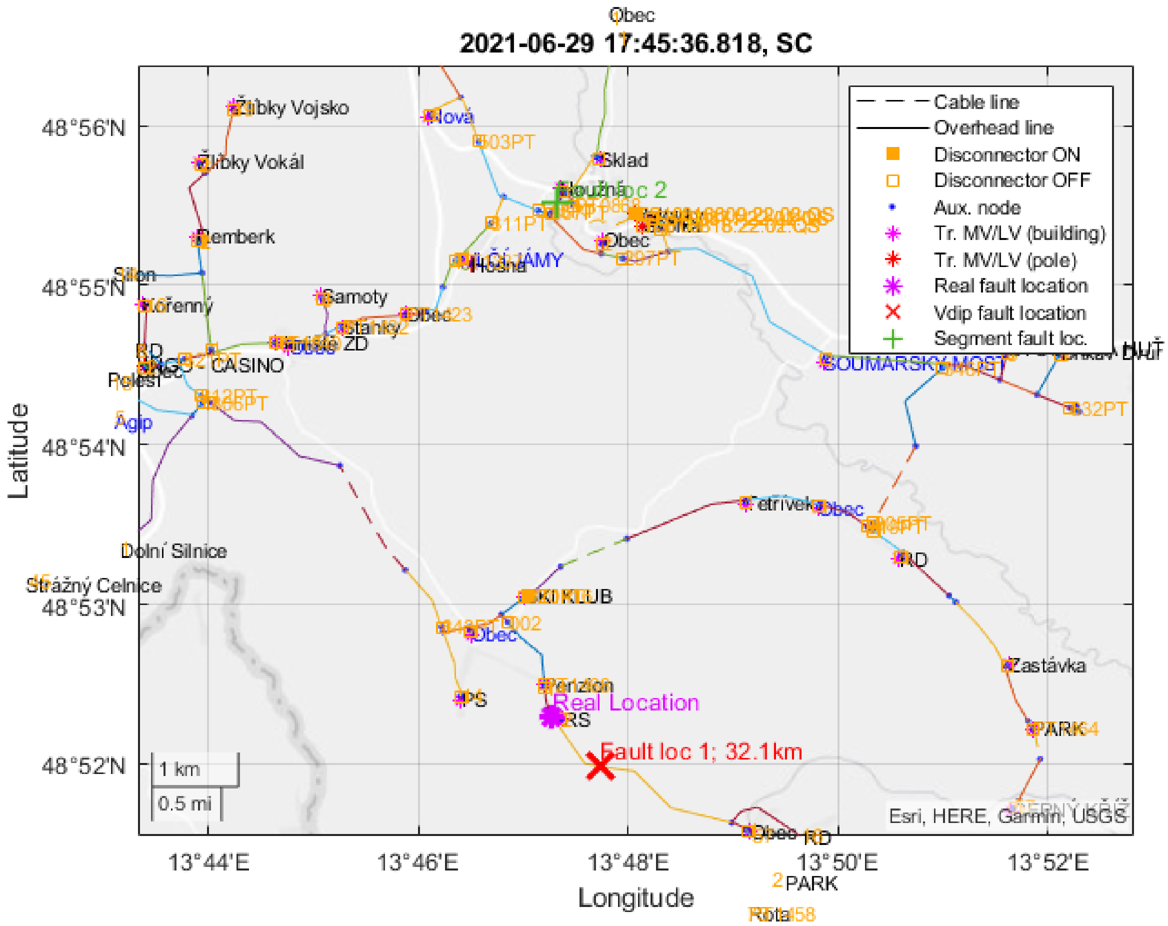

Fig. 9: Presentation of fault location estimated by Vdip method for data of fault record No. 9.

References

[1] TOPOLANEK, D.; LEHTONEN, M.; TOMAN, P.; ORSÁGOVÁ, J.; DRÁPELA, J. An earth fault location method based on negative sequence voltage changes at low voltage side of distribution transformers. *INTERNATIONAL JOURNAL OF ELECTRICAL POWER & ENERGY SYSTEMS,* 2020, č. 118, p. 1-8. ISSN: 0142-0615