Case Study

seba KMT
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Theme: Record in long range TDR measurements on submarine power cables

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Time domain reflectometer (TDR) measurements are an invaluable tool for pre-locating faults on power cables, but there are significant challenges involved in making these measurements successfully on cables that are longer than about 100 km. For operators of the long HVDC submarine power cables that are increasingly being used for the country-to-country transfer of electrical power these challenges are a particular concern, as there are few, if any, cost-effective alternatives for locating faults on these cables.

With this in mind, Seba nor as, a Megger Group company, has recently been evaluating the performance of a new extended-range TDR test set that has been specifically developed for use on HVDC submarine cables. The evaluation was carried out on the NorNed HVDC cable, which is a joint project of Statnett and TenneT, the operators of the power grids in Norway and Holland respectively.

The 580 km long NorNed cable, which operates at 450 kV, is the longest submarine power cable in the world. It runs between Feda in Norway and the seaport of Eemshaven in the Netherlands, and it interconnects the power grids of the two countries.

Background

To establish a baseline for the evaluation of the new instrument, experimental TDR measurements were made on the NorNed cable in 2010, using an existing TDR test set (Teleflex MX) in conjunction with a special submarine cable adaptor (LDE 800). With this arrangement, a cable fault 72 km from the point of connection of the test set was successfully detected, but it proved completely impossible to detect the end of the cable at 580 km.

A sample of the new TDR test set (Teleflex VX) with extended range and new features optimised for work on long cables was presented to Statnett at a meeting in April 2013, where it was agreed that the instrument would be used to attempt to detect the end of the cable during the next planned shutdown of the dc link in September.

Preparation

The NorNed cable was taken out of service and grounded at both ends, in accordance with the scheduled maintenance plan, one week before the TDR evaluation was due to commence, thereby eliminating the risk of the instruments being damaged by return voltage. Extended test leads were also prepared to allow easy connection of the test set.

Measurements

The first measurements were made on phase PK1 of the cable using the new TDR test set connected at the Norwegian end of the cable. The test parameters were carefully adjusted to optimise the results and the averaging function – one of the novel features of the new instrument – was used. This function rapidly makes and compares 256 measurements, and only impedances that are detected as being stable are shown in the final trace.

Reflections were visible from known cable joints and from the remote end of the cable. It was clear, however, that the distant reflections were affected by constantly changing noise and that without the averaging function, the end reflection would have been undetectable.

Photographs of the trace obtained is shown in Figure 1 and it will be seen that there is a small end reflection at approximately 600 km. This trace was, however, obtained before the pulse velocity, v/2, had been fine-tuned by identifying a known joint at 154 km and adjusting the v/2 value so that this distance on the trace matched the known length.

When this had been done, further measurements were made, and these showed the cable end at the correct distance of 580 km. More measurements were then made using the instrument's zoom function, and these revealed another cable joint at 304 km. This matched exactly the information in Statnett's records.

Next TenneT was contacted and asked to remove the grounding at the Netherlands end of the cable, with the object of seeing whether the form of the end reflection would change. The results with the ungrounded cable were compared with results that had been stored in the instrument's memory when the cable was grounded, and the change in form could be clearly seen, providing incontrovertible proof that the instrument had indeed detected the end of the cable.

Finally, the complete test set up was moved from phase PK1 to phase PK2 and all of the measurements were repeated. The results were almost identical with those from phase PK1 with reflections from the joint at 154 km and the cable end at 580 km clearly visible.

Conclusion

After the tests had been completed and the results examined in detail, all parties agreed that the evaluation of the new instrument had been a great success. TDR measurements showing an end reflection at 580 km on a submarine dc power cable had never before been possible, and the impressive results obtained proved that the technology used in the new instrument meets or even exceeds all expectations.

This is a particularly important achievement as further long undersea cables linking Norway with Germany and England are planned and technology capable of locating faults accurately will play a key role in the economical operation of these and of the many existing undersea cables.

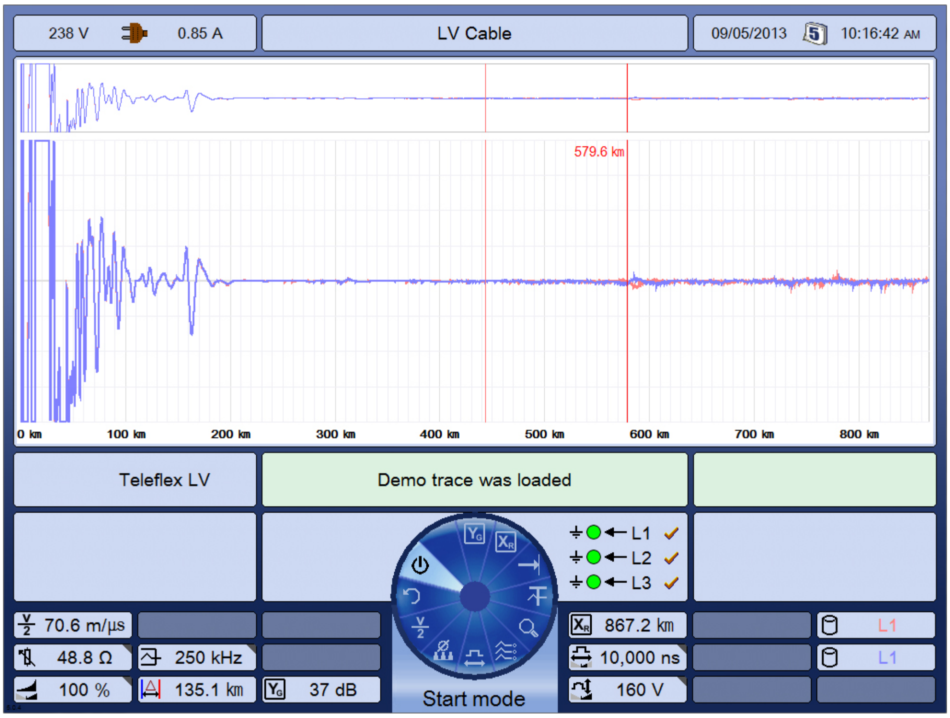

Fig 1: Kurve, die ein Kabelende bei 580 km mit offenem und kurzgeschlossenem Ende anzeigt.

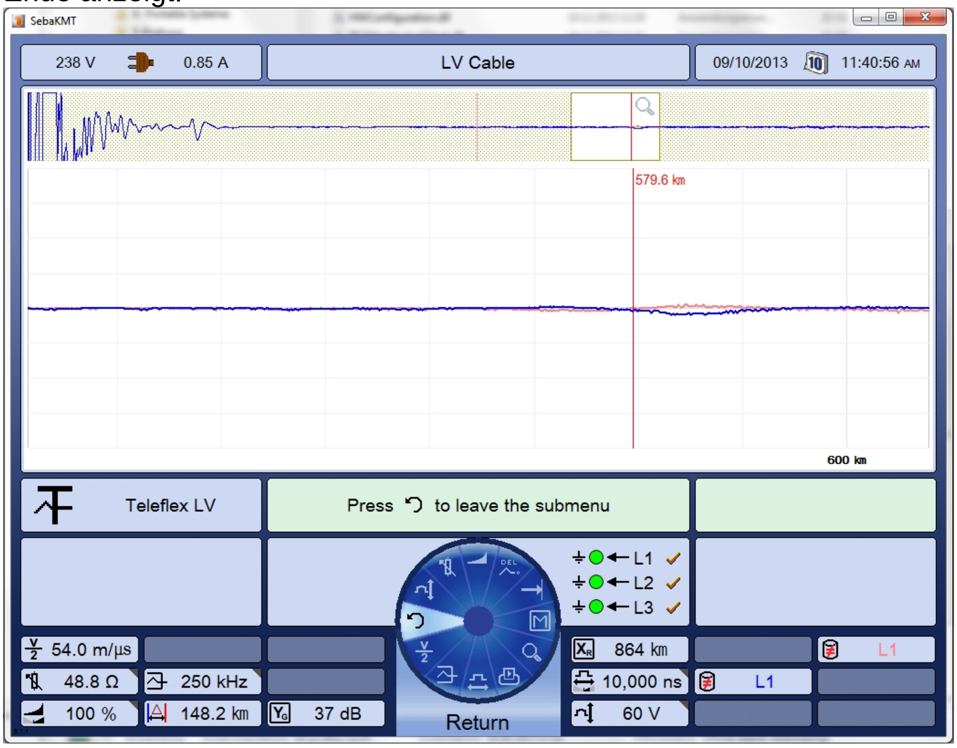

Fig. 2: 10-fach Zoom bei 580 km

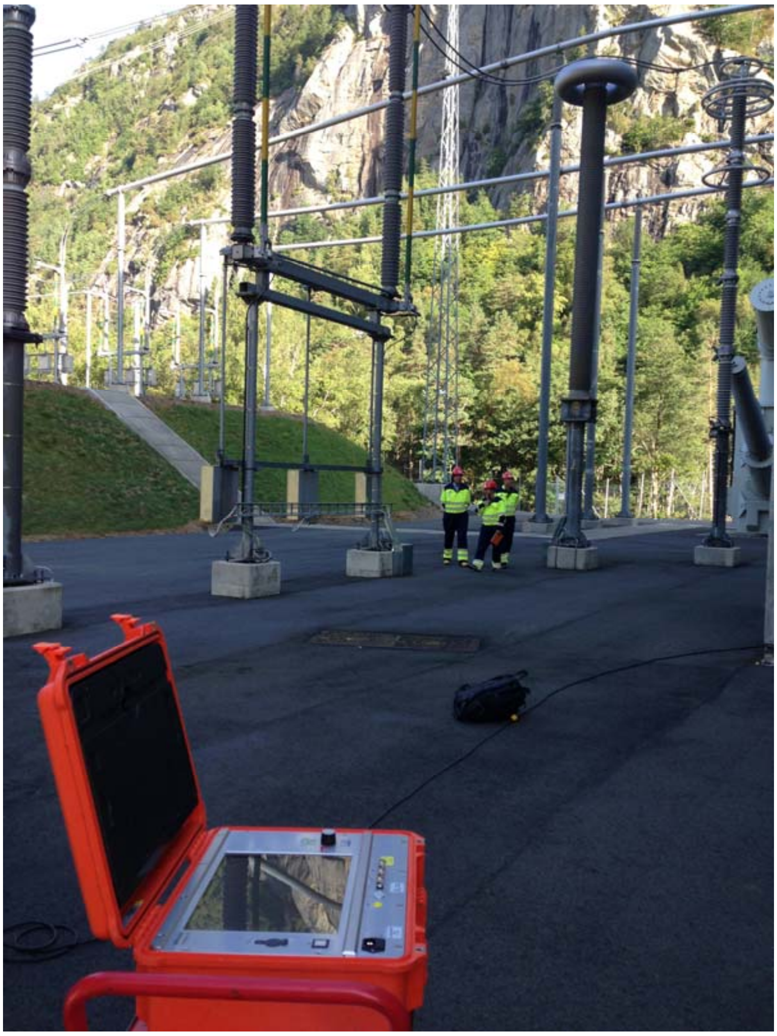

Fig. 3: 450 kV HGÜ-Anlage beim Anschließen mit dem Teleflex VX

Fig. 4: Der Endverschluss, schon der Anschluss ist eine Herausforderung.

Fig. 5: Das Team bei der Messung und Auswertung.