Extending the Functionality of On-line PD Monitoring Equipment for MV Power Cables

You can't put thermometers around every corner because of the sheer amount of MV cables. Signal speed can be used to monitor mean temperature along a cable segment. This is cheap and easily implemented, since PD detection units are already in place. PILC and XLPE cables are tested in a lab. Signal propagation speed is measured at different temperatures. Relative permittivity is measured using a network analyser.

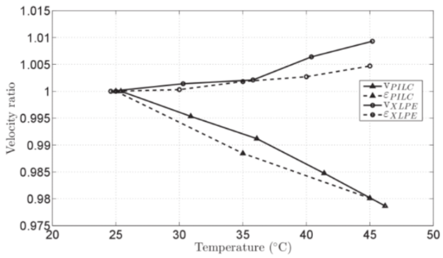
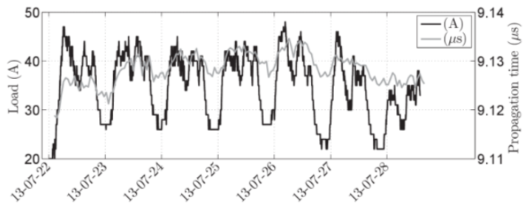
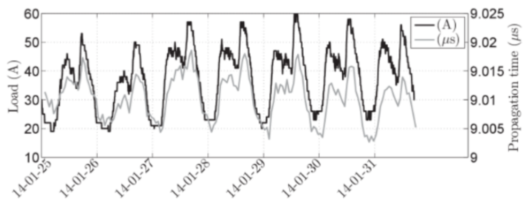


Fig. 7 - Comparison of relative change in velocity with temperature, based on the velocity measurements and the permittivity measurements for both XLPE and PILC cable; the starting temperature is around 25 °C. Note that these temperatures are derived for the insulation midpoint.

An in-field 1464 metre PILC cable is monitored. The propagation time follows the load curve. This is consistent with lab results. The relation is approximately linear. 0.2 % variation in propagation speed corresponds to 5 °C temperature variation.



(a) Propagation time and load of PILC cable for week cycle in summer.



(b) Propagation time and load of PILC cable for week cycle in winter.

Guarding MV Cables On-line: with Travelling Wave based Temperature Monitoring, Fault Location, PD Location and PD related Remaining Life Aspects

HV cables use real-time temperature measurement, but this is too expensive and extensive for MV cables. The same lab setup is used. Speed is derived from permittivity using the formula:

$$v = \frac{1}{\sqrt{\varepsilon_0 \varepsilon_r \mu_0}}$$

A 1 % speed drop corresponds to a 10 °C temperature rise for PILC. A 1.2 kilometre PILC cable is monitored. A transit time of 7.5 µs and sample rate of 50 MHz give a time resolution of 0.3 %. The resolution can be increased by taking the average of 60 signals over 1 hour.

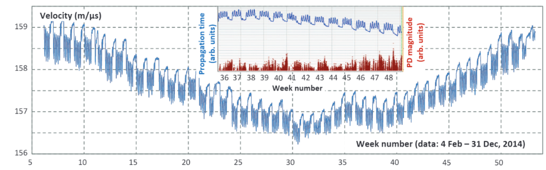


Figure 3. Variation of the propagation velocity over almost a year (48 weeks). Observed is the daily variation on top of a seasonal temperature variation. The inset shows the total cable PD activity, together with the cable transit time (reciprocal velocity), which is significantly affected by the temperature variation.

Seasonal effects and the 5-day working week cycles are clearly present. Daily speed variation is about 0.3 %, corresponding to a 3 °C temperature fluctuation. Yearly speed variation is about 1.2 %, corresponding to a 12 °C temperature fluctuation. Despite the small daily variation, PDs clearly increase in frequency and magnitude with changing temperature. This seems to coincide with the *cooling down* period.