Technology radar monitoring of overhead power lines when detecting ice formations

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***Abstract*: Radar monitoring technology on overhead power transmission lines for detecting ice deposits formation on wires is described here. The results of using this technology at existing power transmission lines are shown.**

Keywords: ice deposits on wires, power transmission line, radar sensing technology, electromagnetic impulse, optimum impulse

LEGEND AND ABBREVIATIONS

PTL *Power Transmission Line*
HF *High Frequency*

Sensing impulses reflected from any available heterogeneous wave resistance from the end of line carry information about appearing ice deposits in radar detecting method.

Formation of ice on wires represents as heterogeneous dielectric, reducing the speed of signal along the line causes additional attenuation due to dielectric losses of electromagnetic wave energy that is consumed in heating of ice layer coating. Radar method allows to determine the occurrence of icing on a transmission line by comparing the propagation time of reflected signals and their amplitudes in presence and in absence of ice formation.

When probing line with pulse radar (reflectometer), totality of the reflected pulses forms a trace. The appearance of ice deposits on line causes change in trace. The more the characteristic impedance of the line will change under the influence of thickness of ice deposits due to changes of dielectric constant between the wires of the line, the more will increase pulse delay $\Delta\tau$ and decrease pulse amplitude U.

Radar sensing technology of ice deposits formation for power transmission line is developed. It includes the following steps:

1. Trial traces are taken and digitally precessed to extract the desired signal from noise in controle line.

2. By using impulse reflectometer length of line is determined. Attenuation in line is calculated to determine the amplitude of sensing source impulse.

For calculation method [1] and software module "attenuation" are used.

As for example, Figure 1 shows the calculation result of signal attenuation in the HF tract of lines with length of 16 630 m and 45 700 m.

According to preliminary calculations of attenuation, the amplitude of radar sensing output signal is estimated. That allows reliably and accurately detect impulses reflected from heterogeneity of the line, with oscillation background in HF tract of PTL.

However, this calculations method has wide assumptions, which is unacceptable in some cases as describing complex process like spreading radar sensing impulses through short-band transmission lines. Especially discrepancies between the

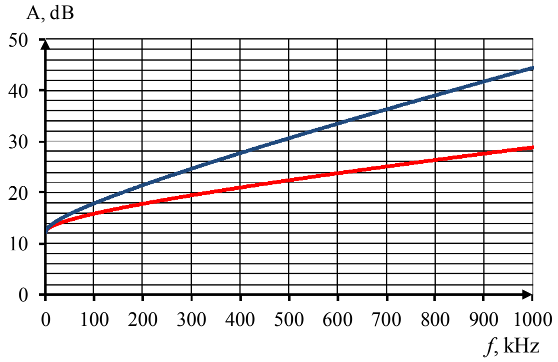

Figure 1. Relation of attenuation with frequency in HF tract, got from lines with length of 16 630 m (red line) and 45 700 m (blue line)

calculated and actual values are observed during formation of rime-ice deposits on wires.

More accurate values of attenuation of each HF tract can be determined individually, as well as combinedly by experiments using special diagnostic apparatus. But measuring of frequency response of HF tract experimentally is not always possible.

In such cases, modeling of HF tract of PTL with special packages such as Matlab Simulink gives more reliable values of calculation.

Shape of reflected pulses from the end of line are also determined. Optimum duration of sensing impulse is selected. Shape of sensing pulse transforms by increasing duration, but the main impulse retains its shape and amplitude, providing a stable measurement of reflected pulse delay (Figure 2).

Reference trace is measured and saved in memory.

3. Interfering condition of controlled line is studied in detail.

4. Sensing mode is defined, parameters of sensing impulse are set.

5. Taste traces are taken and sensing modes are adjusted to optimize them.

6. The value of delay $\Delta\tau$ obtained by measuring and reducing the impulse amplitude ΔU are used to recalculate the thickness of ice deposits. If the line consists of several radar areas then weight and thickness of the ice are calculated for each of them separately.

7. The calculated values of ice deposits are transferred to controle room of power distribution company where these are displayed in user friendly format. In case of detecting ice deposits which can cause accident in power transmission lines, melting decisions is taken.

Over 7 years of experimental research, this technology is proved as a useable. Comparison of radar monitoring device readings and direct observations of ice on power transmission lines is a proof. As an example in Figure 3 shows the dynamics of changes traces in regular intervals of 5-6 December 2011, during the beginning of the intensive growth of snow layer on wires of power transmission lines.

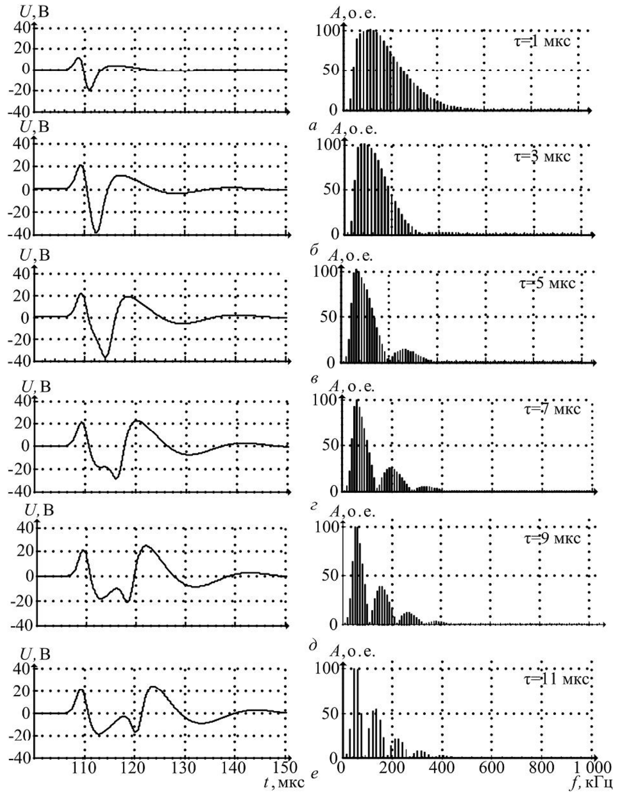

Figure 2. The shape of rectangular impulse with different durations and corresponding spectrums through HF tract of PTL

Fragments of traces with detailed changes in shape of reflected impulses from the HF stopper mounted on PTL at a distance of 40 300 m (left column) and 70 000 m (right column) during formation and growth of ice-snow deposits are shown in Figure 3

Figure 3 shows a clear tendency of reducing amplitude of first oscillations *U* and increasing its delay $\Delta\tau$ at reflection points according to growth of thickness of snow layer.

Synchrono-proportional decrease of *U* and increase of $\Delta\tau$ for impulses indicate that the ice-rime layer throughout the entire length (70 000 m) has the same thickness.

In presence of snow clutch with diameter of 2 cm, which is not harmful for integrity of wires, reflected impulses on line are reduced in amplitude *U*, and delay $\Delta\tau$ increases by 5-6 μs, which is a stable and reliable sign to appear deposits on wires of PTL.

Thus, radar monitoring system and developed technology provide reliable early detection of rime-ice formation on wires of overhead power transmission lines.

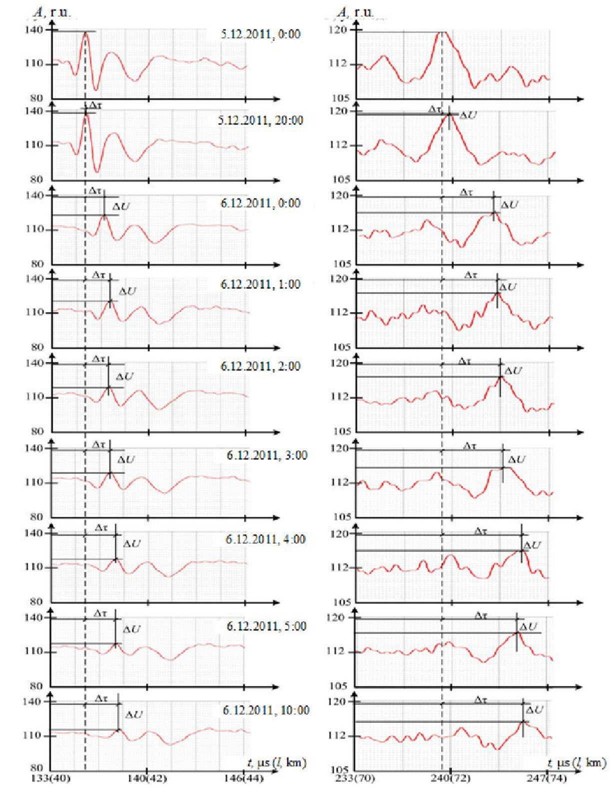

Figure 3. Detailed dynamics of changing fragments of traces of overhead PTL with length of 40 300 m, followed by HF bypass on overhead PTL with length of 29 700 m during period 5.12.2011 - 6.12.2011

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REFERENCES

[1] Yu. P. Shkarin “High frequency tracts of communication channel over power transmission lines” — Moscow: NTF "Energopress", 2001. — 72 p.