



NEW WAY OF HIGH FREQUENCY TRANSIENTS PROTECTION

PS 2

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INTRODUCTION

One of the **main tasks** of power engineering is **equipment protection** from the effects of high-frequency and pulse overvoltages caused by lightning strikes and commutations.

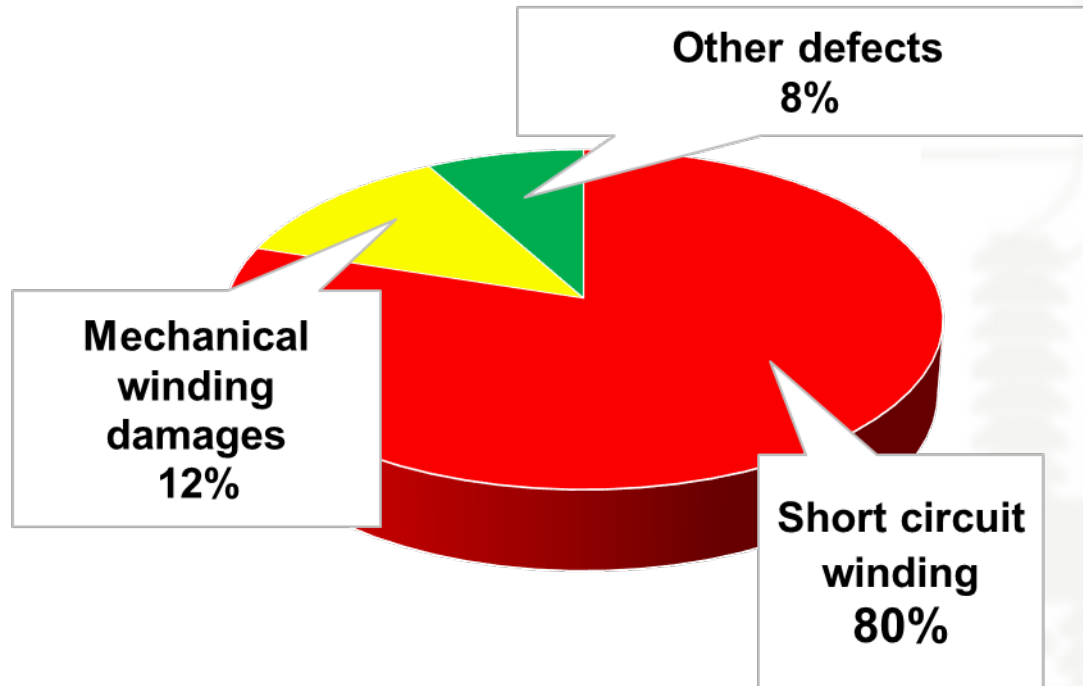
An additional protection is needed for power lines that were built on high resistance ground, in areas with:

- permafrost
- relict sandy grounds
- hard rocky ground



Distribution of permafrost in Russia

MAIN DEFECTS OF TRANSFORMERS

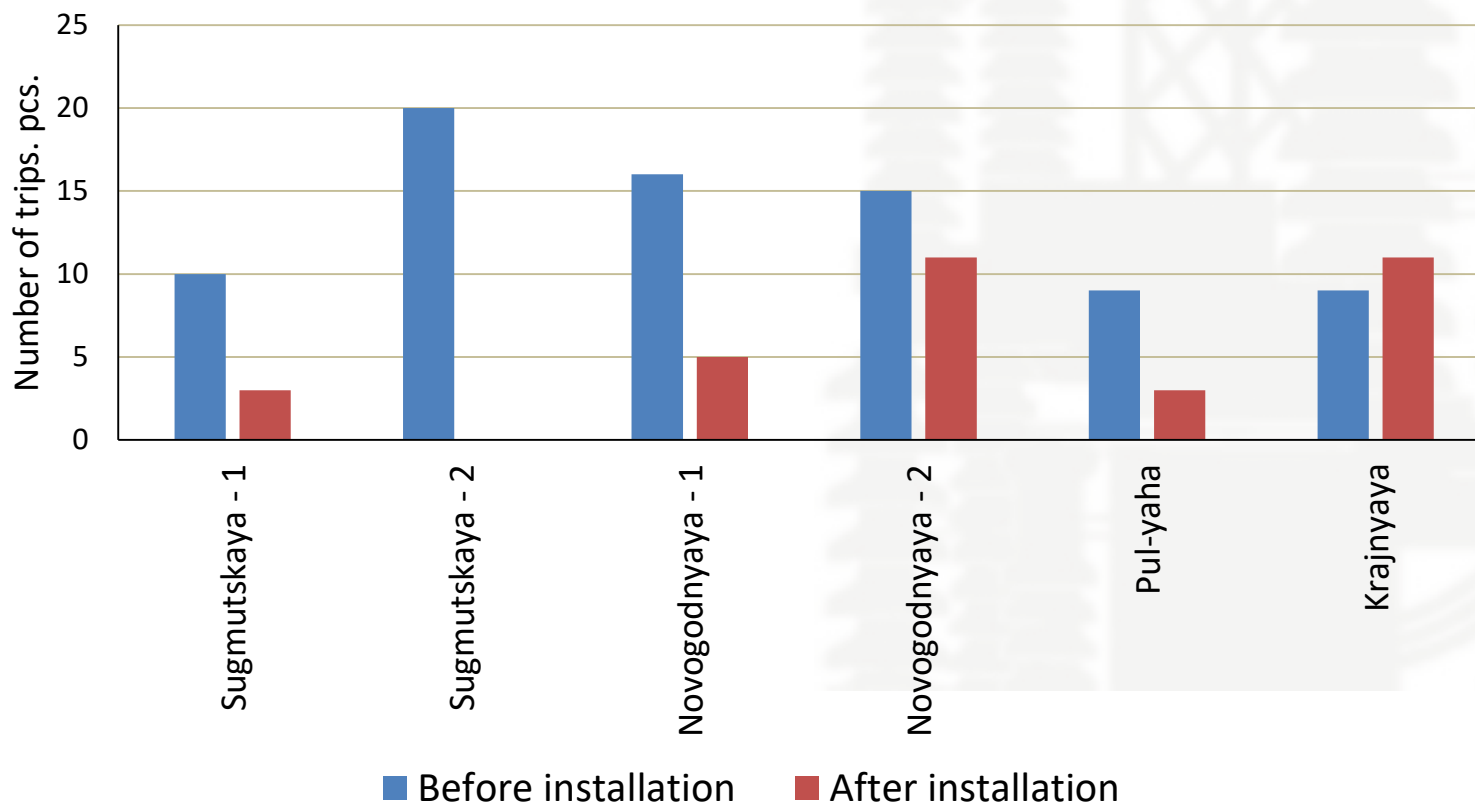


Turn-to-turn short circuit
in the transformer

The defect distribution diagram
for 110 kV transformer equipment
with a rated power of 16 - 40,000 kVA
JSC "Tyumenenergo"

THE EFFECTIVENESS OF SURGE ARRESTERS IN THE NORTHERN REGIONS

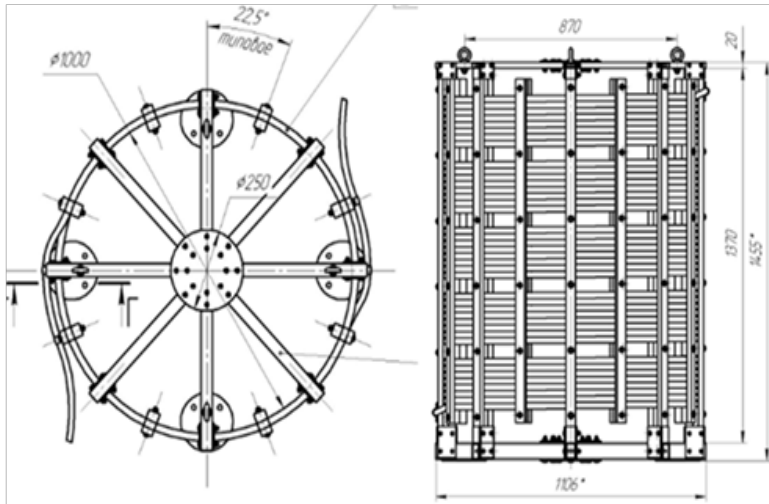
The diagram of the number of emergency shutdowns before and after surge arresters installation on overhead power lines in JSC "Tyumenenergo"



FREQUENCY-DEPENDENT DEVICE

Frequency-dependent device (FDD) – the way of working is based on the principle of skin effect

Since 2014, three devices have been put into trial operation



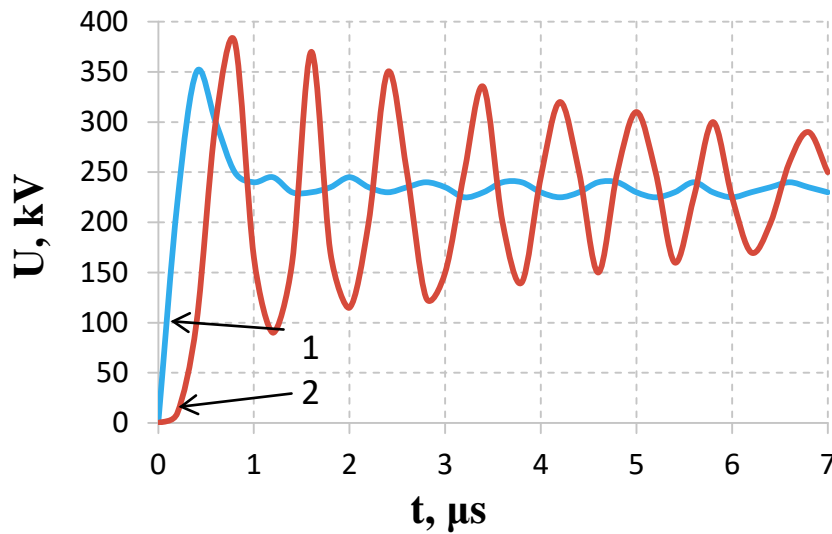
General view of the FDD



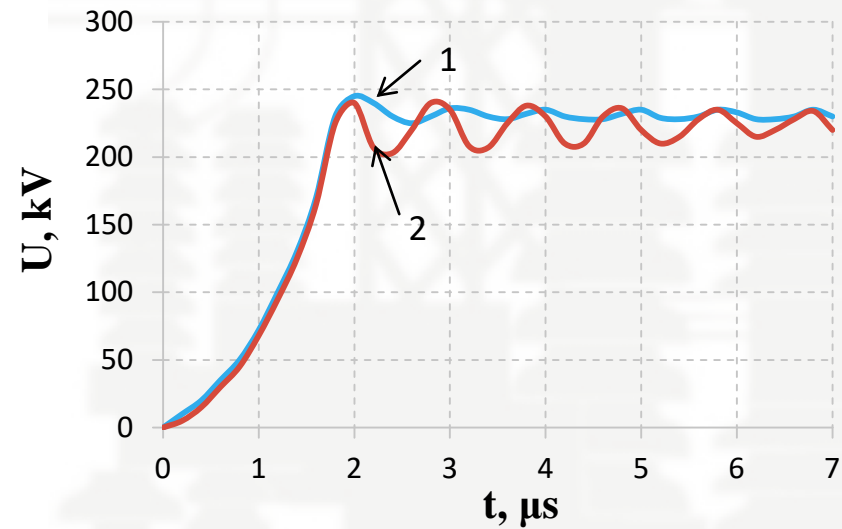
The device on the portal of substation "Sugmutskaya" JSC "Tyumenenergo"

ANALYSIS OF FDD EFFICIENCY

Computer modelling



Without FDD



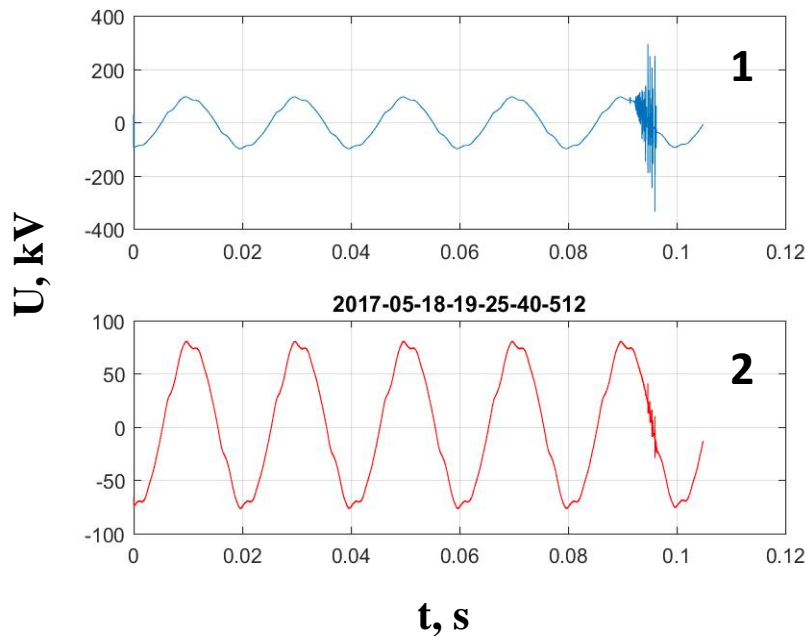
With the connected FDD

1 – input pulse
2 – output pulse

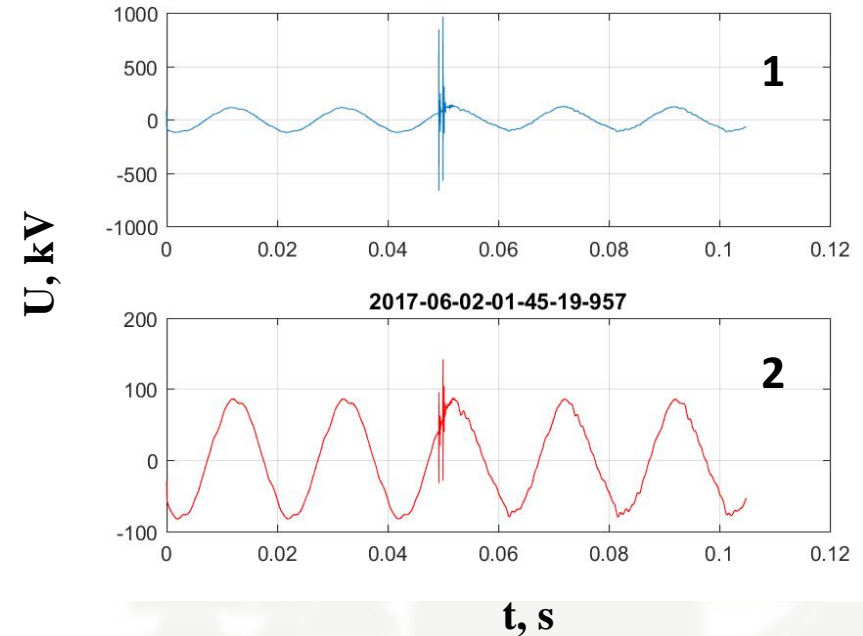
ANALYSIS OF FDD EFFICIENCY

Monitoring results

The incident wave (1) and wave after FDD (2)



18 May 2017



2 June 2017

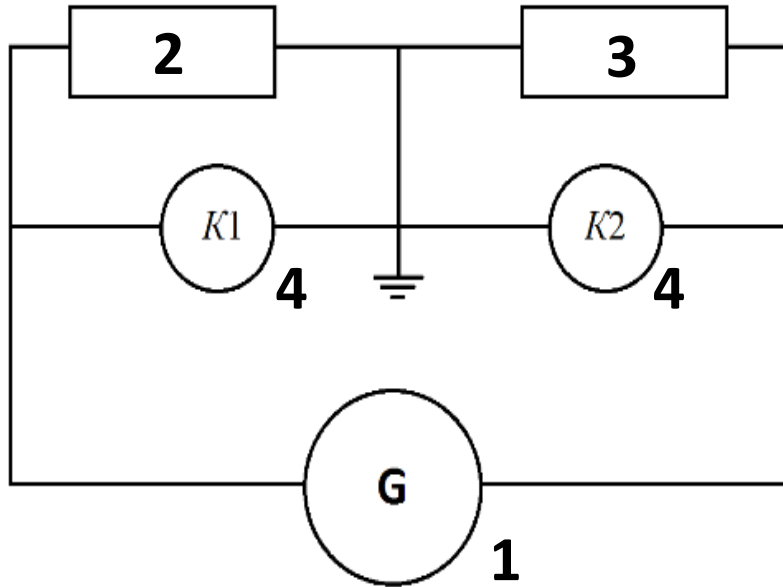
THE PURPOSES OF THE RESEARCH

1. The growth of active resistance at high frequency
2. Reduce the frequency-dependent device dimensions

THE RESEARCH TASKS

- Investigation of the influence of material properties, form, hardware design on the FDD effectiveness by using laboratory samples
- Investigation of the influence of various factors on the lightning-proof of overhead power lines

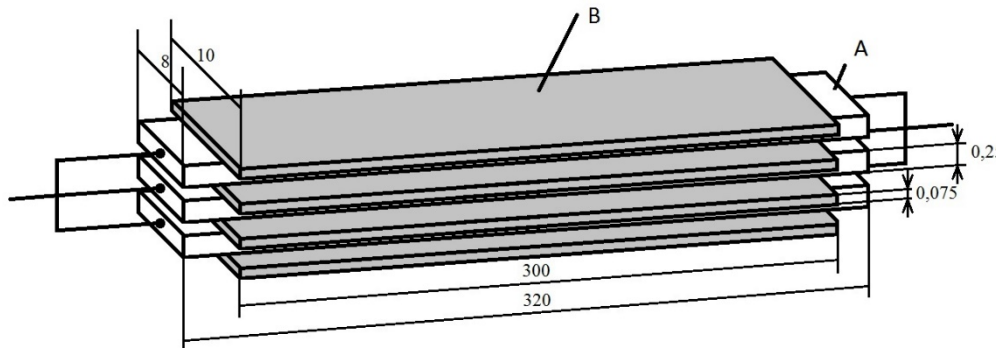
THE LOW-VOLTAGE TESTING



Circuit diagram

- 1 - frequency generator
- 2 - shunt resistance 0,5 Ohm
- 3 - sample of FDD
- 4 - K1 and K2 – oscilloscope probes

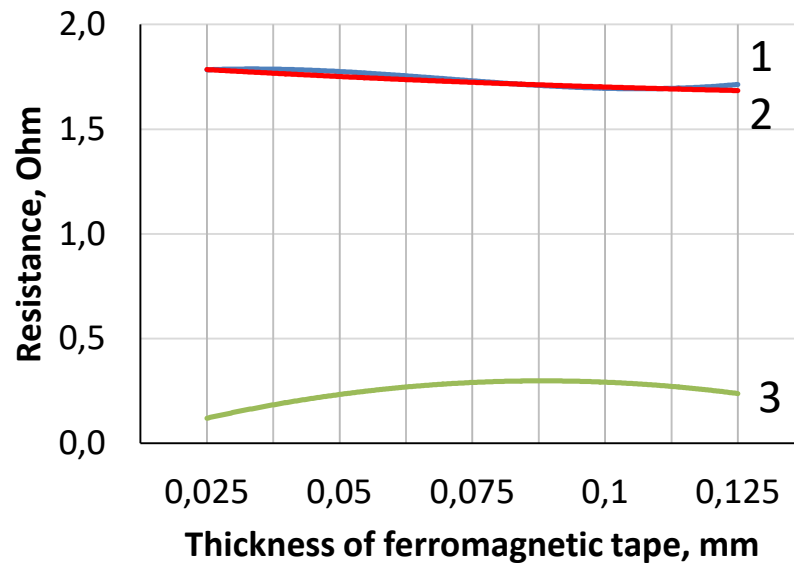
The scheme of the FDD with a flat conductor



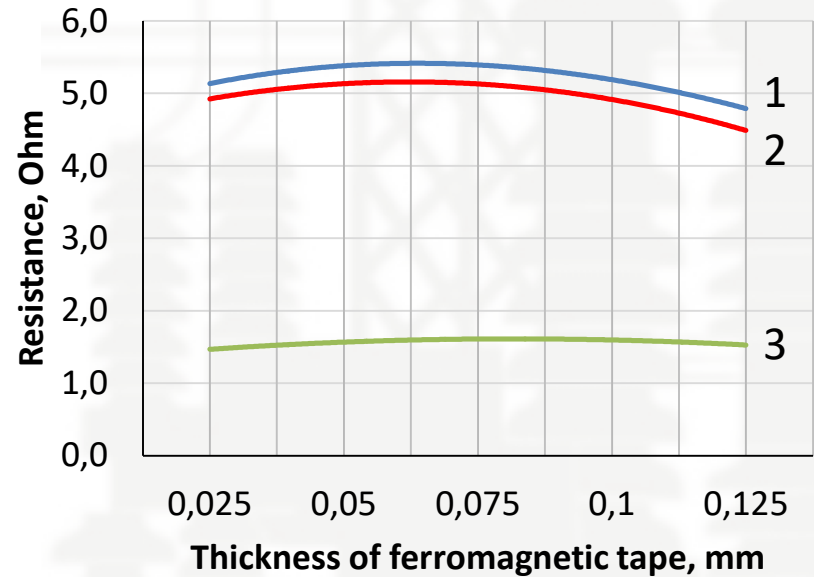
- A - copper tape
- B - ferromagnetic tape

THE DETERMINATION OF TAPE THICKNESS

Resistance of samples, at a frequency of 300 kHz



Computer modelling

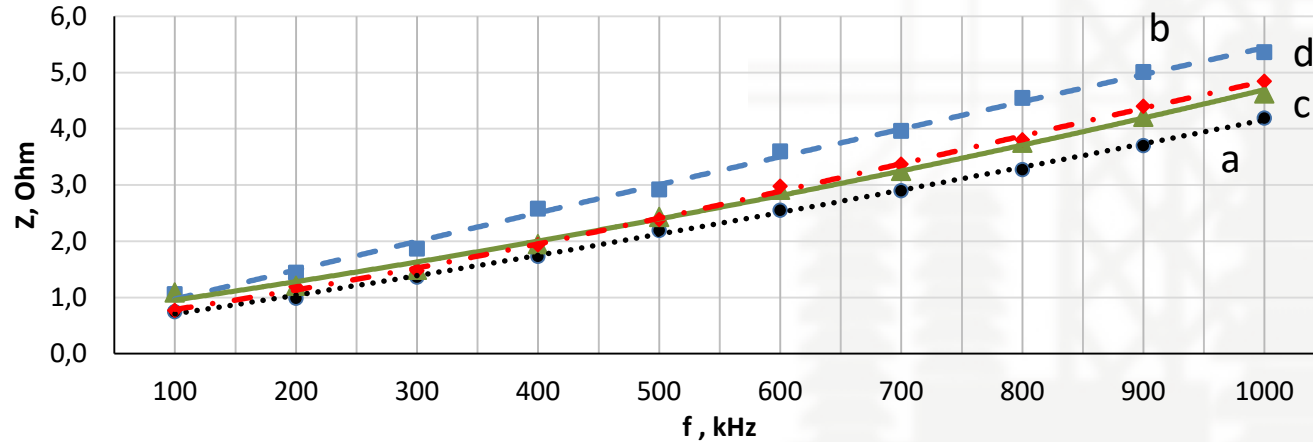


Experiment

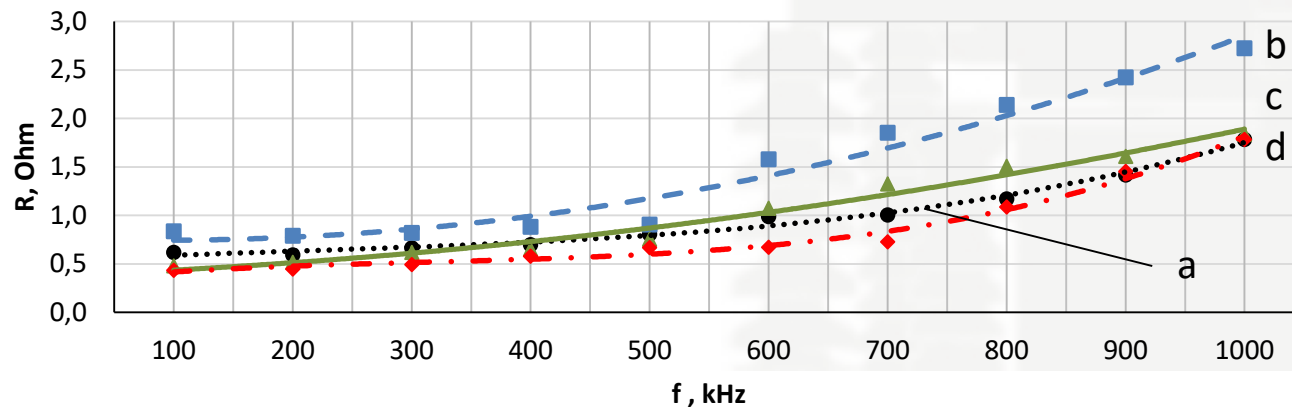
- 1 - Impedance, Ohm
- 2 - Inductive resistance, Ohm
- 3 - Active resistance, Ohm

THE INFLUENCE OF THE CONDUCTOR LAYERS NUMBER

The dependence of the sample **impedance** on the frequency

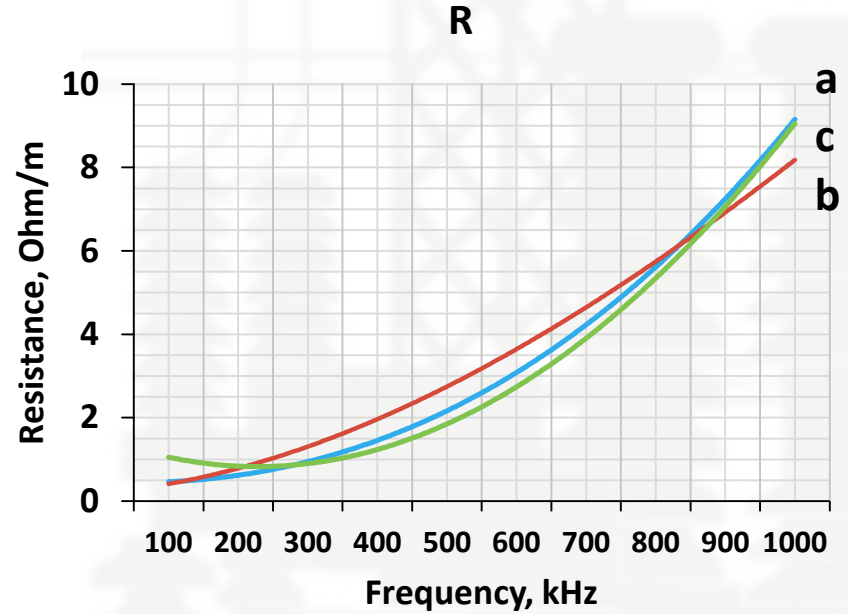
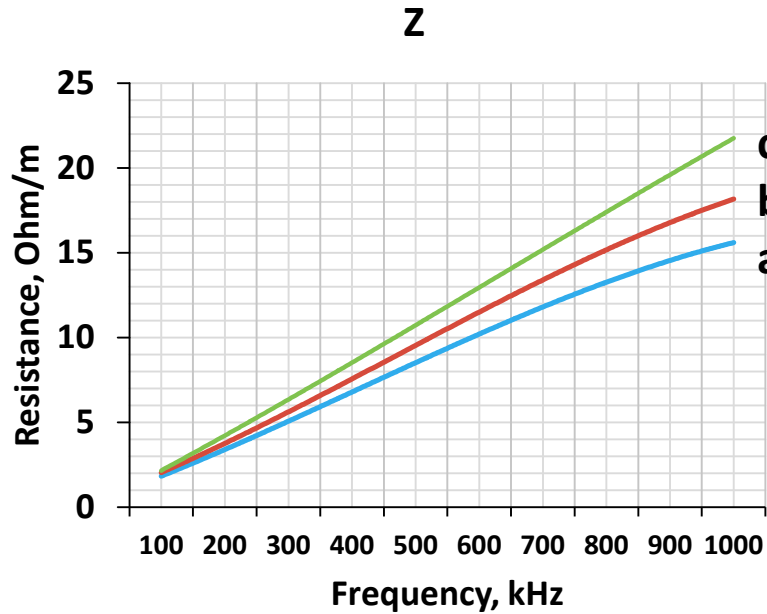


The dependence of the sample **resistance** on the frequency



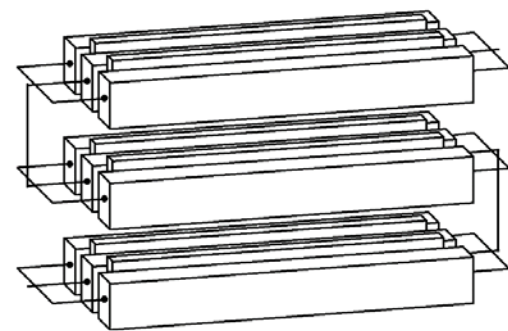
a - single conductor layer; b - 3 layers; c - 5 layers; d - 15 layers

THE INFLUENCE OF DISTANCE BETWEEN ELEMENTS



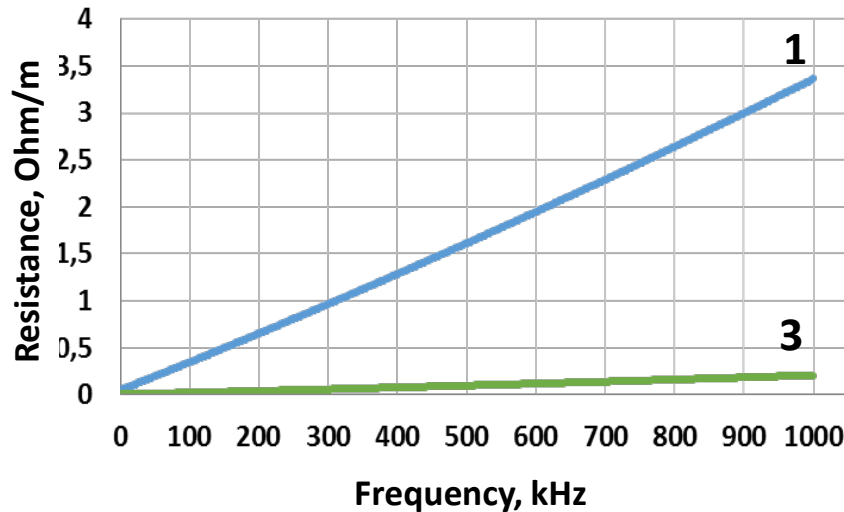
Distance between strips
a - 2 mm, b - 7 mm, c - 10 mm,

Sample circuit FDD

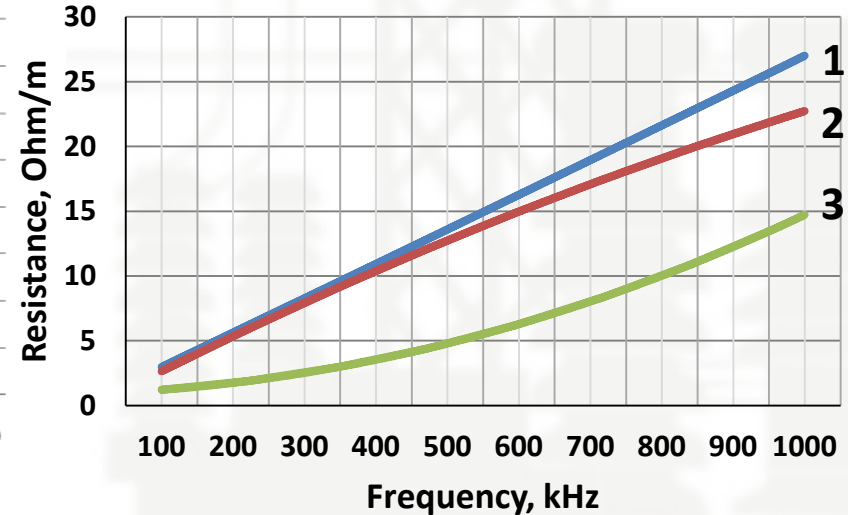


THE USE OF A WHOLE TAPE

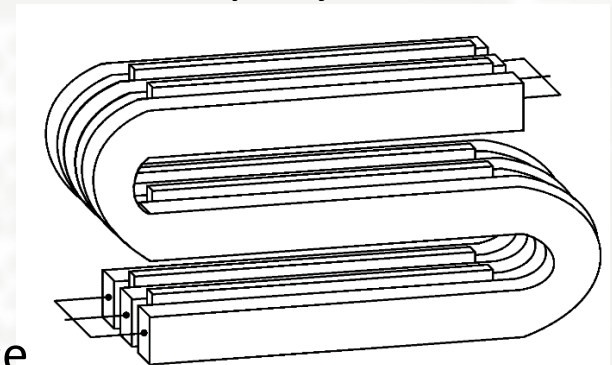
Prototype FDD*



«Flat» FDD



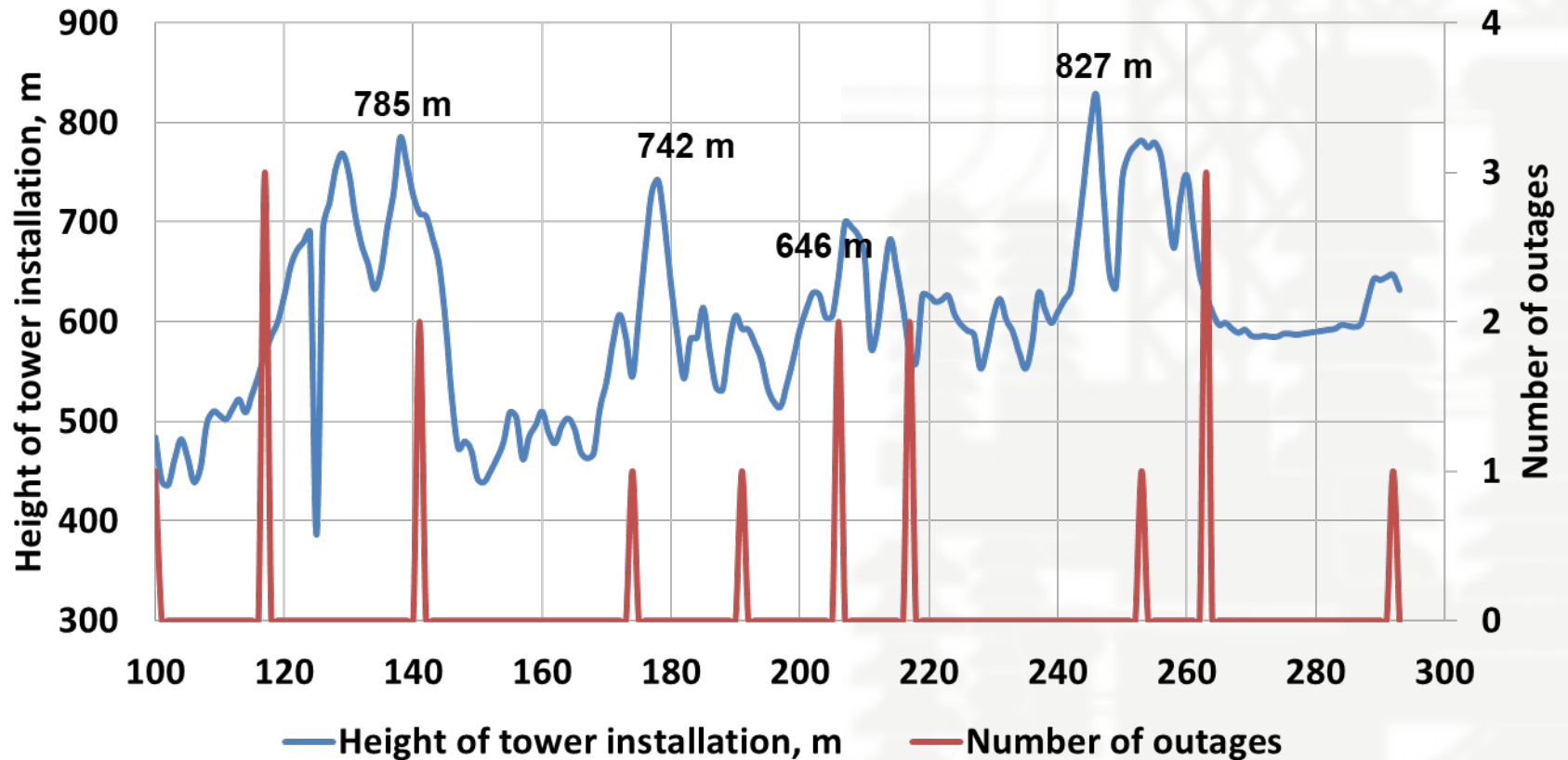
- 1 - Impedance, Ohm
- 2 - Inductive resistance, Ohm
- 3 - Active resistance, Ohm



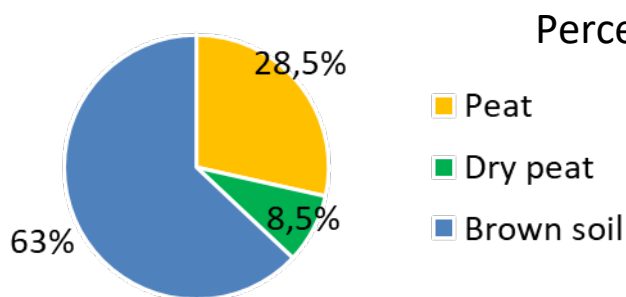
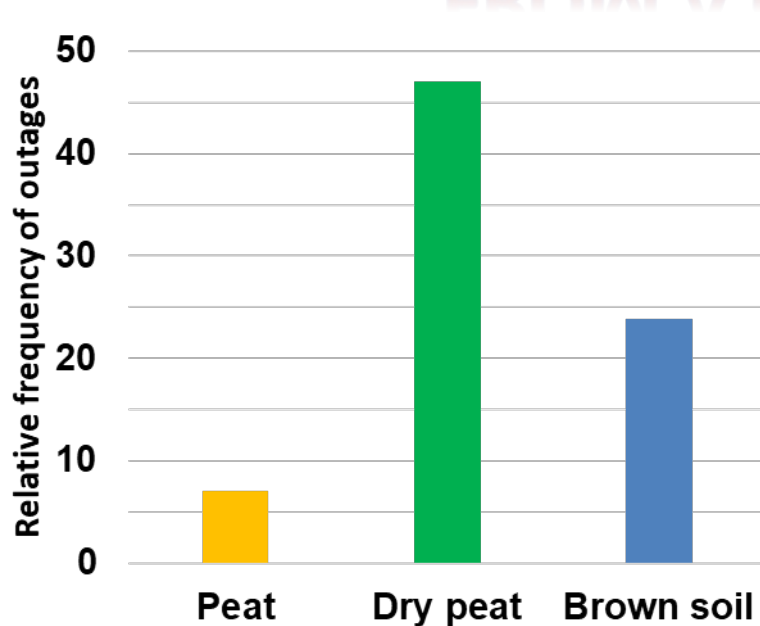
The sample «flat» device

*N.Ya. Ilyushov "Development and investigation of a frequency-dependent device for suppressing high-frequency overvoltages", Ph.D. dissertation, Dept. Power Eng. NSTU, Novosibirsk, 2014.

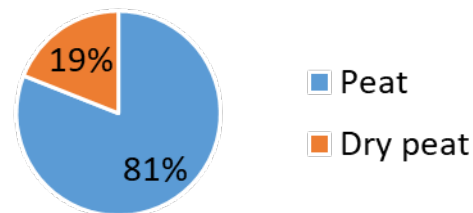
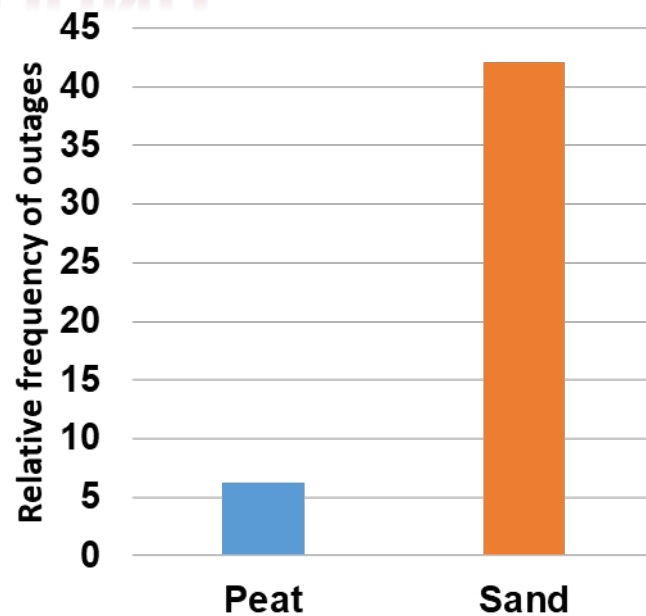
THE DEPENDENCE OF OUTAGES NUMBERS FROM A RELIEF



THE DEPENDENCE OF OUTAGES NUMBERS FROM A GROUND



OHL 220 kV Urgal-Ettercan
Khabarovsk region



OHL 220 kV Vyngapur – Novogodnyaya
Yamal-Nenets Autonomous Area

RESULTS

Investigations of the influence of various factors on the device effectiveness were carried out.

Samples show the greatest impedes and active resistance at the following parameters: thickness of ferromagnetic tape 0,075 mm, three conductor layers, distance between elements 2 mm, permissible minimum dimension in terms of corona and electrical strength.

Using optimal parameters and a whole tape allowed to increase the FDD sample efficiency by 7 times.

Investigation of the influence of relief, ground on the lightning resistance of OHL showed the following:

- The impact of the relief is minimal on the numbers of lightning strikes.
- The lightning strikes often occur on the ground with more resistance, for example sand.

FURTHER WORK

- Making spiral samples of long length
- Performing of low-voltage and high-current measurements of samples
- Carrying out of computer modeling for definition of an optimum design
- Calculation and production of full-length device
- Simulation of transients in a power network with the connected FDD
- Testing the device and installing it for trial operation