Asbesco
Damping Study
Client: TU Project
Project: 220 kV OHL;
Single ACAR 1000, ACS 7#8 AWG, OPGW-48B1-128
01/06/2016, rev 11/06/2016

1. General

This damping study was done with the "ATTRA"-software from Prof. Diana from the Polytechnico di Milano (he is also convener of the CIGRE working groups B2.31 and B2.46. Both working groups are dealing with wind induced conductor motion of single and bundled conductors) based on the tender documents submitted to ASBESCO.
The software is computing the required strain on the basis of energy balance. For each frequency a balance of energy introduced in the system by the blowing wind through the vortex shedding phenomenon and the energy dissipated by the conductor and the dampers is achieved. Out of the conductor deformation calculated fromthe energy balance principle the conductor strain is computed at certain points of interest. Fig.1shows the flowchart of the software.

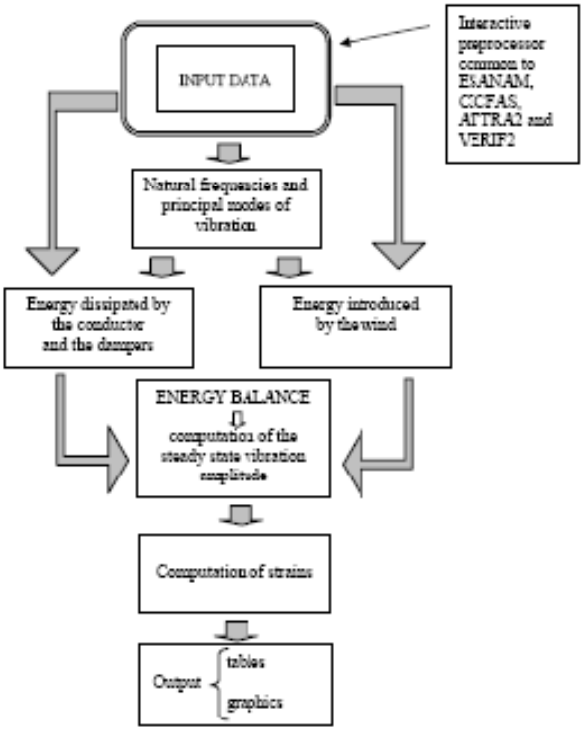

Fig.1: Flowchart of the software

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2. Summary

It is shown in detailed damping studies that the amount of vibration dampers meets the requirement for the conductors ACAR 1000 and both the earth wires ACS 7#8 AWG and OPGW-48B1-128. The requirements were chosen from Cigre paper "Recommendations for the evaluation of the lifetime of transmission line conductors" (published from Cigre SC22 WG04, March 79)

- Strain at the conductor clamps for the phase conductor less than 150 micro strain
- Strain at the conductor clamps for the earth wires less than 150 micro strain

The requirements were met successful with the given displacement schemes.
The details on the vibration dampers and displacement charts are given in the detailed chapters showing the result of the vibration studies.

3. Vibration study for single conductor ACAR 1000

According to occurrence of aeolian vibrations the study was done for wind speeds in the range from 0,5 to 7 m/s. With the Strouhal formula (1) the frequency range can be calculated in which the vibration study has to be done.

$$f = 0.2 * v/D \qquad (1)$$

In the above mentioned formula f is the frequency, v is the wind speed and D is the conductor diameter. This formula led for ACAR 1000 to a frequency range from 3.4 Hz (for 0.5 m/s wind speed) to 48 Hz (for 7 m/s wind speed). From the x-axis of the figures showing the results it can be clearly seen that the vibration study was done within the required frequency range.
The conductor used on that transmission line is ACAR 1000 with an outer diameter of 29.26 mm single conductor arrangement. According to the specification a displacement chart and the vibration damper AVD-4R-3 (see annex I) was chosen to avoid aeolian vibrations on the conductor. The calculation was done with the EDS of 22.5 kN (20% of the conductor UTS). The EDS was given by the client.
This study was done for a span length of 400, 600 and 800 m. The displacement chart is shown in Table 1 (annex II). The calculation was done with and without armour rods to simulate suspension as well as tension clamps.

Span length (m)	**50…600**	**601…800**
Displacement from the clamp (m)	1.2	1.2 / 2.0
Number and placement of damper in the span	One damper, both sides	two dampers, both sides

Table 1: Displacement chart vibration damper ACAR 1000

The results of the study are shown in Fig. 2 and Fig. 7.
The blue line shows the strain at a single conductor without damper, the red and the black line resp. (Fig. 2 to Fig. 4) the maximum strain occurring at left or right suspension clamp with dampers installed, the dark green line shows the maximum strain occurring at the damper clamp. The other colors show the strain at the end of the armour rods. In Fig. 5 to Fig. 7 the blue line shows the strain at a single conductor without damper, the red and the green line resp. the maximum strain occurring at left or right suspension clamp with dampers installed, the pink line shows the maximum strain occurring at the damper clamp. All curves display the microstrain as a function of the frequency.

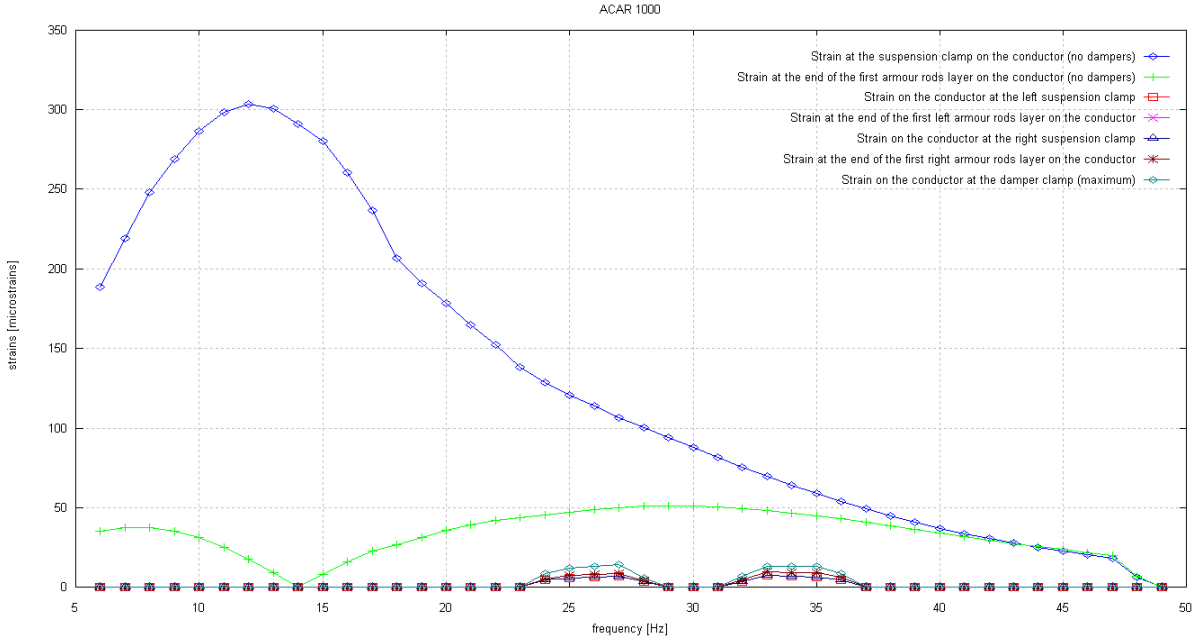

Fig. 2: Maximum strain at certain points at the suspension clamp with armour rods, span length 400m, ACAR 1000, one damper

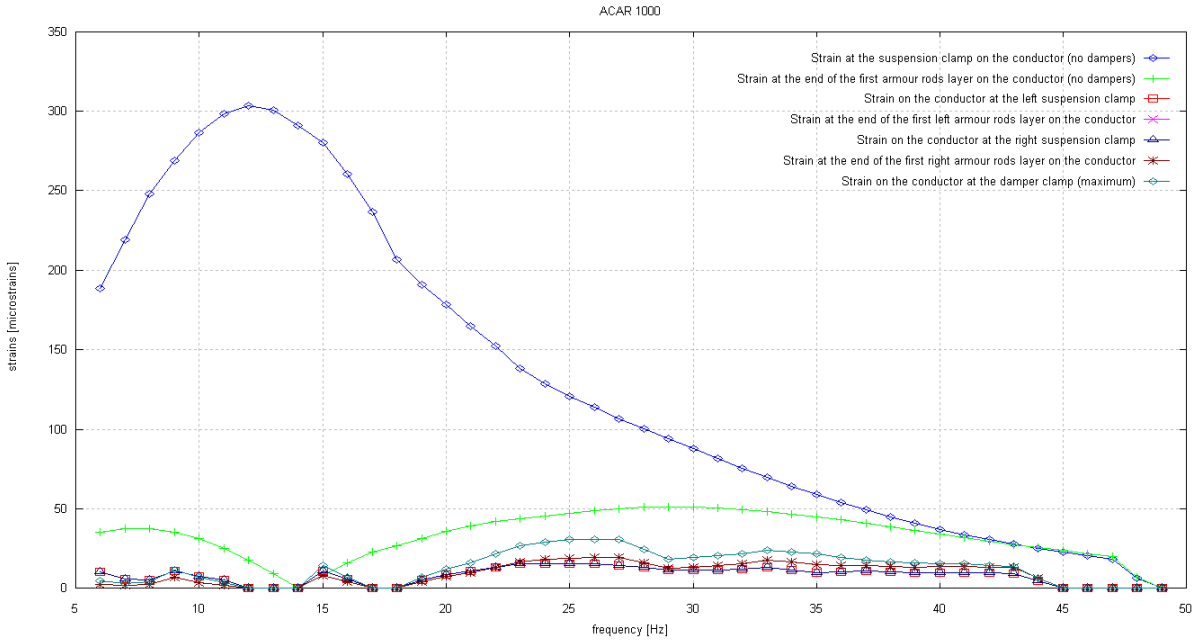

Fig. 3: Maximum strain at certain points at the suspension clamp with armour rods, span length 600m, ACAR 1000, one damper

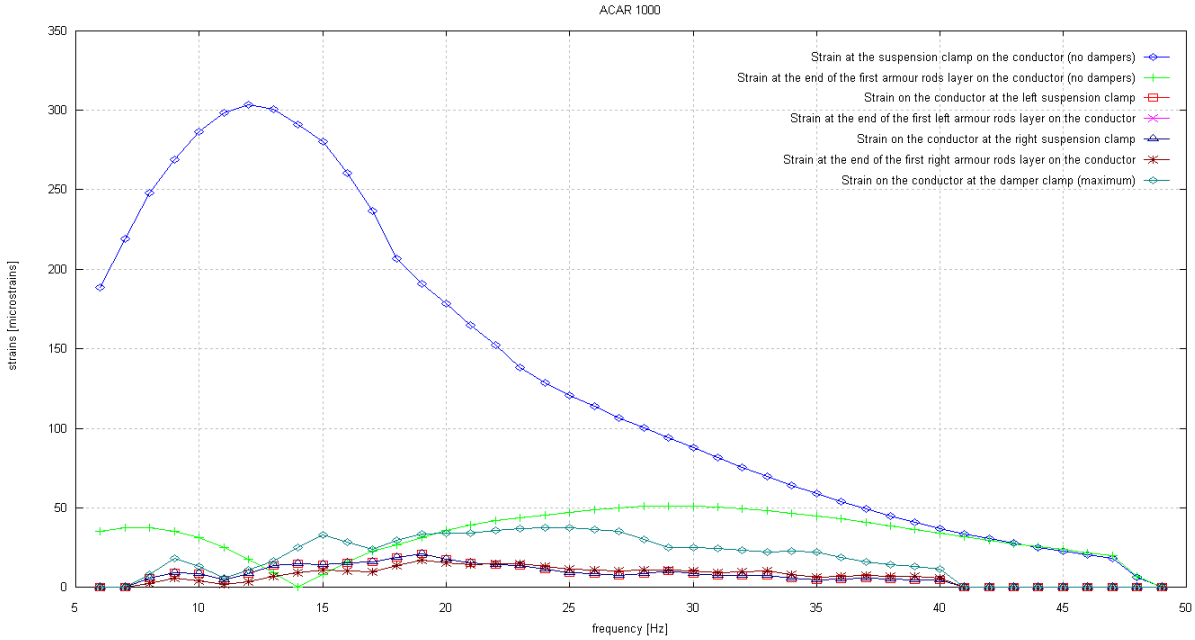

Fig. 4: Maximum strain at certain points at the suspension clamp with armour rods, span length 800m, ACAR 1000, two dampers

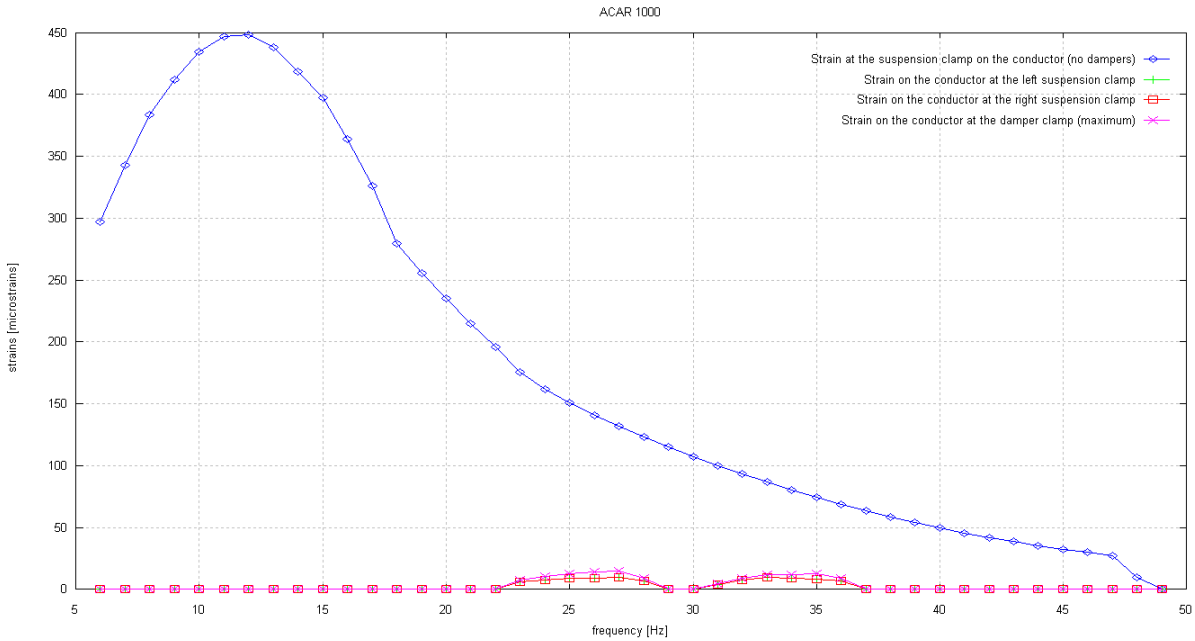

Fig. 5: Maximum strain at certain points at the tension clamp, span length 400m, ACAR 1000, one damper

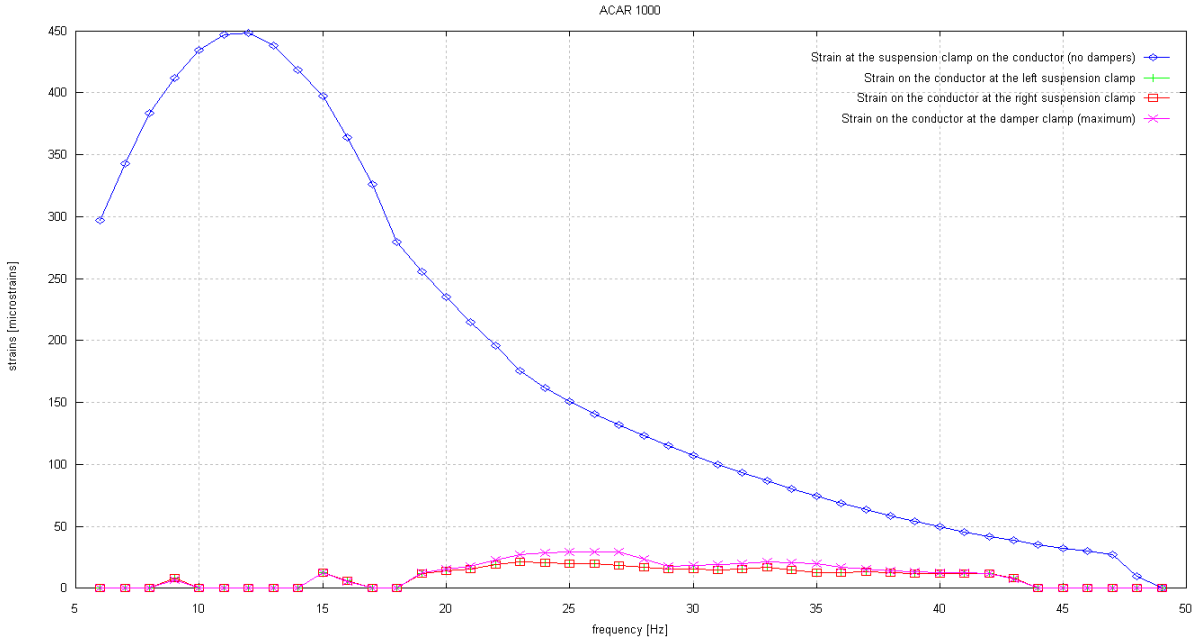

Fig. 6: Maximum strain at certain points at the tension clamp, span length 600m, ACAR 1000, one damper

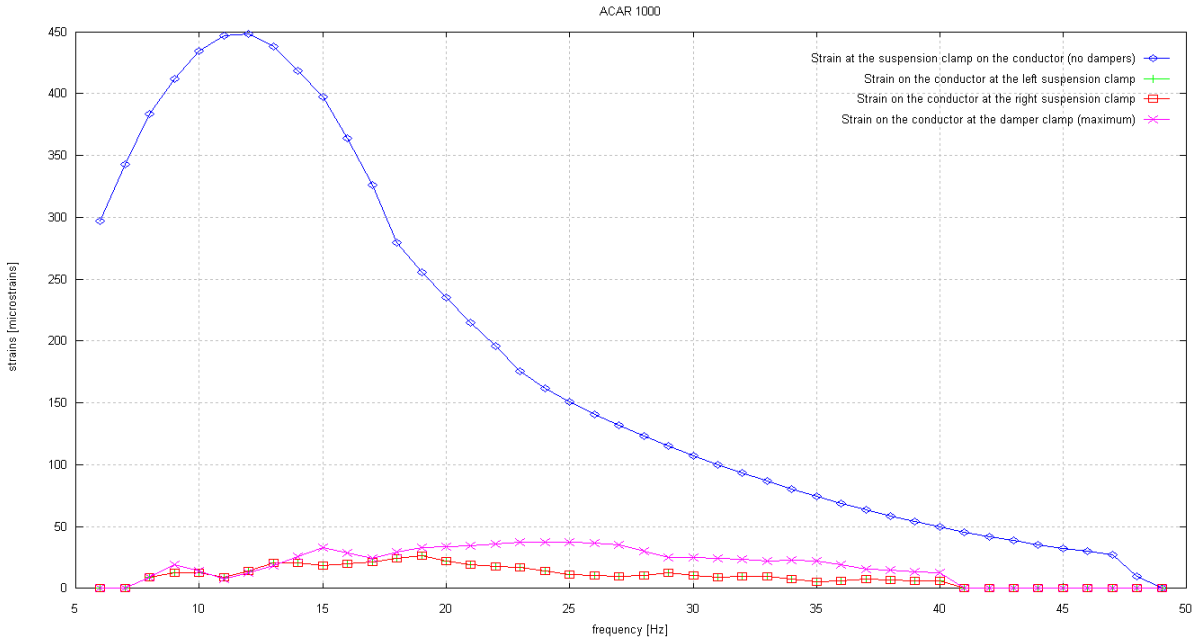

Fig. 7: Maximum strain at certain points at the tension clamp, span length 800m, ACAR 1000, two dampers