Vortex-excited vibrations of long span overhead transmission lines

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Abstract

Wind induced vibrations of overhead transmission lines due to Karman vortex shedding can cause considerable damage to suspension towers and lead to material fatique at points of higher conductor curvature, e.g. points of attachment of the dampers.

Methods of calculations are presented for estimating the response of the dynamical system of long spans to the exciting wind force, where for long spans, there often is the need for a large number of in-span fittings (stockbridge dampers and aircraft-warning spheres).

The critical frequence range lies between 3 and 5 Hz (depending on the wind velocity) and the max. amplitudes of vibration can reach the size of cable's diameter. The well known Energy Balance Principle, which involves radical simplifications, is well established for estimating the vibration levels for spans only damped near the suspension towers, [1]. For very long spans in range of a few thousand meters (e.g. fjord or river crossings) there is often the need to install additional in-span dampers and aircraft warning markers. The simple approach with the EBP is no longer feasible, since the location of the fittings in the span as well as their dynamic characteristics are of importance. The vibration levels may differ considerable along the span and this is reflected in the vibration modes.

In the present paper we investigate long spans with dampers, which are mounted in groups (2 to 6 dampers in each group) not only near the ends of the span but also in-span. If the computation is intended for

part of a practical industrial design, the most important result should be the dynamic stresses or strains of the cable at the dangerous points, i.e. points of attachment of the dampers and the suspension clamps. Mode shapes that come out of approximate methods such as the Ritz-Galerkin method or discrete methods such as FEM are not likely to be adequate for these purposes, since the frequencies of interest (typically 3-50 Hz) lie in the range from the 500th to the 1000th eigenfrequency for a long span transmission line and it is well known that the computational error of approximate methods increases rapidly with a rise in order. For the model of a long span with in-span fittings, the span is subdivided between two suspension points into $n+1$ subspans by n conductor fittings. In the first step the transcendental eigenvalue problem is formulated for the conductor with in-span fittings and a modified approach applying EBP to the individual complex vibration modes is decribed.

In this investigation long-span transmission line conductors are also equipped with multiple dampers near the suspension clamps. In this case the line is modelled as highly tensioned straight beam acted on by concentrated frequency dependent forces. Exact and explicit expressions for frequency equations and mode shapes are obtained with the aid of an integral transformation [2]. Numerical examples show that the usual sinusoidal mode shapes can be significantly distored by a group of dampers to give rise to dangerous strains.

References

[1] Verma H., Chakraborty G., Krispin H.-J., Hagedorn P.: On the modelling of wind induced vibrations of long span electrical overhead transmission lines, Proc. 5 Int. Symposium on Cable Dynamics, 2003.

[2] Wang H.Q., Miao J.C., Luo J.H., Huang F. and Wang L.G.: The free vibration of long span transmission line conductors with dampers.