OpenPLA - A novel pole-line analysis software with advanced modeling capabilities

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1 Introduction

This short document highlights the capabilities of OpenPLA, which is a nonlinear pole-line analysis (PLA) software developed by the authors. All theory is based on first-principles physics, therefore no assumptions or simplifications are made. Further, the algorithm is highly generalized and therefore handles any transmission system configuration or loading scenario that may be encountered in the field. Many of these capabilities exceed those of leading industry-standard programs.

2 Capabilities

2.1 General configurations

The program can handle any complex generalized transmission system configuration. For instance, Fig. 1 shows a system with eight poles, of which seven are anchored using guy wires. Poles may be connected to any number of support wires, and support wires may be connected to any sequence of poles in any order. Additionally, poles may be anchored using any number of guy wires to any number of anchors. Anchoring using any number of horizontal support rods is also permitted.

2.2 Heavy equipment loading

Conventional nonlinear catenary theory has been augmented to capture localized loading from any quantity of heavy equipment attached to support wires. For example, Fig. 2 shows two heavy pieces of equipment mounted along a single support wire between two poles. The first piece of equipment is attached 13 m from the first pole and weighs twice as much as the second component, which is attached 26 m from the first pole. It is clear in the figure that the weigh different causes the maximum sag to occur at the location of the first component.

2.3 Intersecting cables

Another advanced feature of the algorithm is its ability simulate any number of intersections between cables in a fully coupled manner. In Fig. 3, two different support wires intersect the same cable at arbitrary locations. Since the cables are fully coupled to one another, the shape of the cable being intersected deforms in order to equalize tensions.

2.4 Anchoring sidebars

OpenPLA also models any number of horizontal support rods mounted along poles. Figure 4 shows a system with two poles, of which one pole is anchored using two different horizontal support rods. The rods may be mounted at any height and orientation, and any number of guy wires may be connected to each rod.

2.5 Wind loading

Wind loading on cables and poles is considered. Any wind speed and direction may be specified by the user, and OpenPLA then computes the resulting loads that act on the poles and cables. It is therefore possible to determine how much cables sway sideways under extreme wind conditions. Figure 5 shows an extreme example with 60 m/s

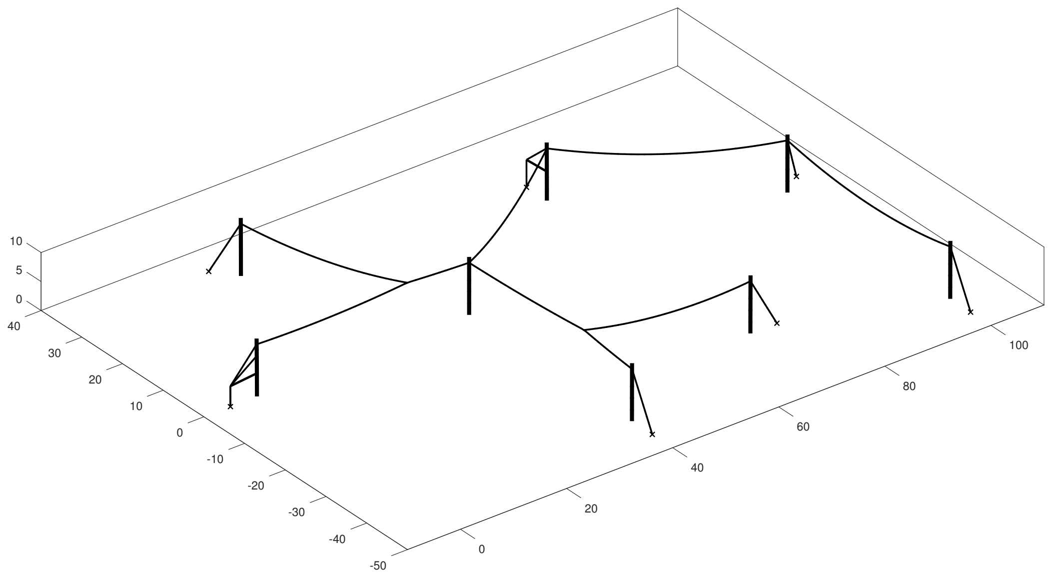

Figure 1: General transmission system layout.

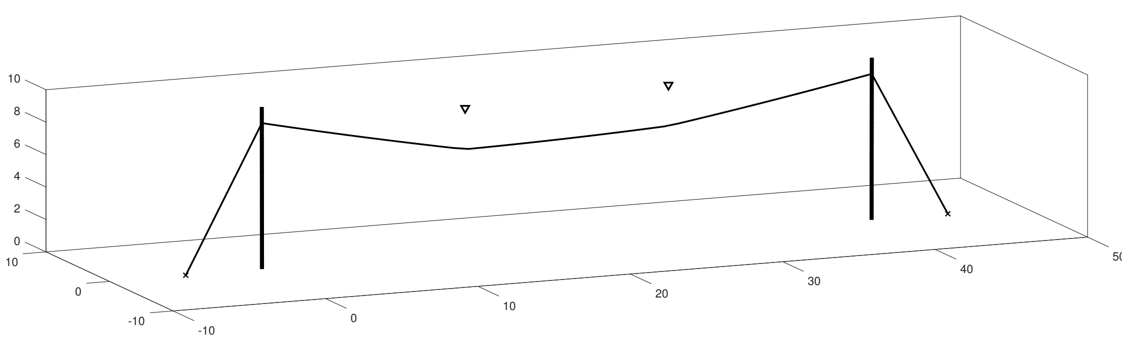

Figure 2: Single span with multiple heavy equipment attached.

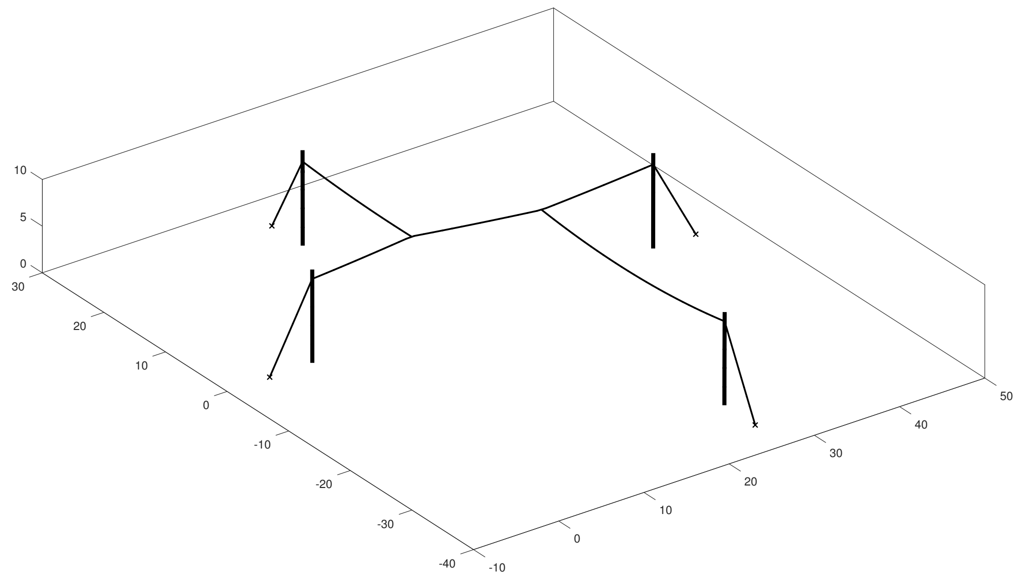

Figure 3: Single span intersected by multiple cables.

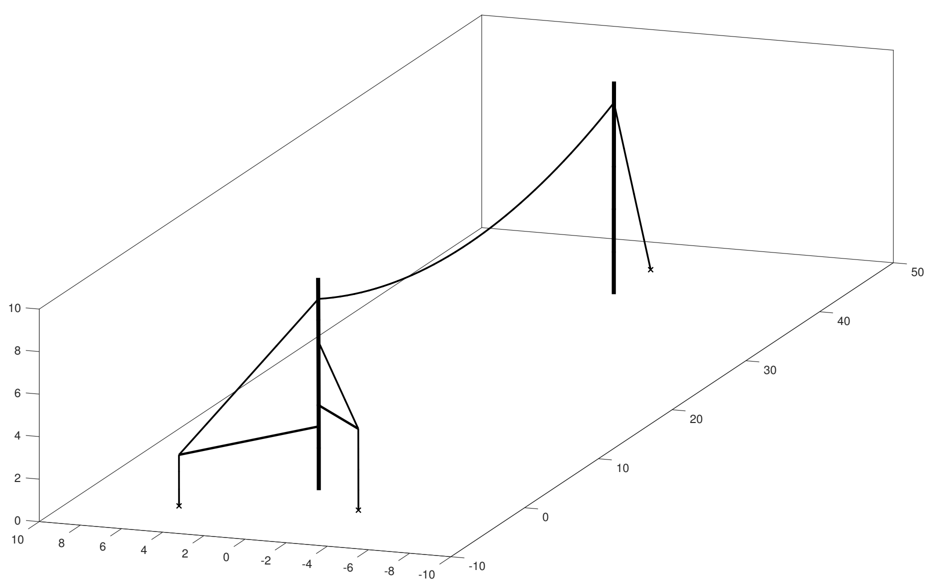

Figure 4: Horizontal support rods used for anchoring.

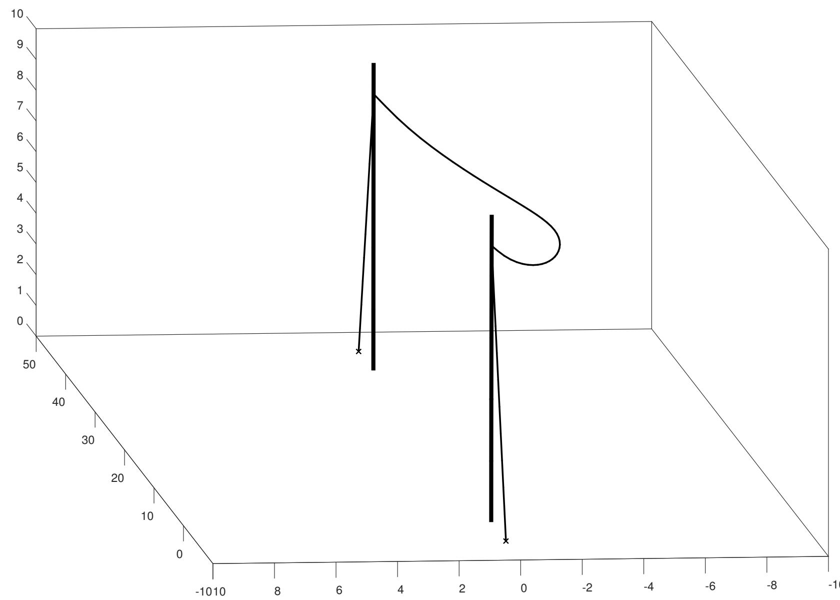

Figure 5: Cable sway under extreme wind loading.

wind directly perpendicular to a low-tension span. The wind is blowing toward the right as shown in the figure, and the sway of cable is apparent.

2.6 Other features

Other features that cannot be shown visually include the following:

- Temperature effects are taken into account by shrinking or expanding cables.
- Icing and lashings may be mounted along any support wire to increase its weight.
- Pole deformations are simulated using finite element analysis (FEA). In the case of dead-end poles, pole deformation is coupled to guy wire elongation. This feature provides a more realistic and conservative estimate of anchoring loads when poles are deflected or cables are shrunk due to temperature drops. Horizontal support rod deformations are also simulated and coupled to guy wire elongation.
- The nonlinear catenary model used to simulate cable tensions and sags considers cable elasticity. In other words, cable stretch under high loads is considered. This phenomenon plays a significant role at high cable tensions.