

# **Propagation in waveguides with metamaterial walls**

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In metallic waveguides, the propagation is ruled by the waveguide section. However, if the boundary conditions on the walls are chosen properly, performances can be improved: the cut-off frequency of the waveguide can be reduced; propagation can be reversed (left handed modes). A methodology is proposed to design such structures. This methodology is based on an analytical formulation of the dispersion equation, in which metamaterials are characterized as surface impedances, combined with a finite element method which calculates the surface impedances.