

This thesis investigates the problem of topology reconstruction for circular planar passive electrical networks, which is fundamentally an inverse problem. The primary objectives of topology reconstruction are: (1) to determine the unknown network structure and (2) to compute the edge conductance values using available electrical measurements. A key aspect of inverse problems is the inherent non-uniqueness of solutions, meaning that a given set of electrical measurements may correspond to multiple distinct network topologies. These measurements are typically acquired from accessible terminals of an unknown electrical network. However, in many practical scenarios, not all terminals are available for measurement, necessitating the reconstruction of the network with limited boundary data. In this work, Thevenin's impedance is utilized as the electrical measurement.

To address the reconstruction problem, this thesis proposes four methods — two analytical approaches and two optimization-based techniques. The optimization-based methods rely on limited Thevenin resistance measurements, which are processed through multiple stages to reconstruct the network. The approach begins by estimating the resistance distance matrix, which is then used to compute the Laplacian matrix that characterizes the network topology and edge conductance. Due to incomplete measurements, the estimated Laplacian matrix contains errors, making direct inference of the network structure challenging. To mitigate this, all possible disjoint paths are extracted from the estimated Laplacian matrix and systematically processed to reconstruct the underlying topology.

The analytical methods take a different approach by formulating a system of multivariate polynomial equations that relate the unknown Laplacian matrix to the Thevenin resistance measurements. To ensure physically valid solutions, various constraints, including Kalmanson's inequalities and triangle inequalities, are imposed on the system. The solution to this constrained system yields a set of valid network topologies consistent with the available Thevenin impedance measurements. The effectiveness of the proposed methods is demonstrated through numerical examples.