Detailed program of the course “SYNTHESIS AND DESIGN TECHNIQUES FOR RF FILTERS”

Introduction – Definition of filters- Specifications: Filter Mask - Design approaches for distributed-parameters filters – Recall of microwave circuit fundamentals for filters design: equivalent circuit concept, resonators, resonant modes, coupled resonators, examples and discussion.

Basics of lumped filters synthesis: equivalent low-pass domain, frequency transformation, impedance conservation property. Approximation of the filtering function: analytical solutions for all-pole functions (Butterworth, Chebycheff). Equations for the elements of ladder low-pass prototype. De-normalized band-pass network suitable for microwave implementations (all resonators of the same type). Redundancy of the network. General relations among the parameters. Practical implementations: all-equal resonators. Example: iris-coupled waveguide filters.

Various types of all-pole in-line microwave filters. Solutions with assigned inverters (microstrip and coaxial implementation). Coupled lines filters. Array of coupled lines: comb and interdigital filters.

Passband filters with asymmetric transmission zeros. Definition of characteristic polynomials. Assumptions for small bandwidth synthesis. Approximation problem: pole-zero placement, generalized Chebicheff function. Evaluation of characteristic polynomials (lossless condition). Complex zeros for phase equalization.

Synthesis of normalized low-pass filters with transmission zeros. Cross-coupled topologies, canonical prototypes. Normalized coupling matrix and its properties. Evaluation of the coupled matrix for canonical prototypes and reconfiguration. Direct synthesis of the low-pass network by means of extraction of components. De-normalization of the low-pass network. Universal parameters of the filter: resonating frequencies, coupling parameters, external Qs.

Re-configuration of the coupling matrix. Cascaded-block configuration. Basic blocks and associated properties. Rules for the cascaded blocks generation. Special topologies: box sections, cul-de-sac.

Extracted-pole filters. Alternative solution for introducing transmission zeros. Direct extraction of a transmission zero (imaginary root of the transmission polynomial). A new element in the equivalent circuit: the non-resonant node. Synthesis of extracted-pole low-pass equivalent networks. De-normalization problem: extension of the coupling coefficient concept to networks with non-resonating nodes.

The practical design approach to high selectivity RF filters. Choice of electrical parameters for satisfying the assigned attenuation mask. Effect of introducing transmission zeros with finite unloaded Q resonators. Introduction of design margins for compensating temperature drifts. Choice of filter topology. Effect related to the power flowing through the filter: excess voltages across the real resonators and possible produced effects. Examples of microwave filters implemented with extracted-pole configuration.

Approach to the dimensioning of narrow band microwave filters. Selection of the physical resonators (cavities and modes). Approximated (initial) dimensioning based on the synthesized coupling coefficients. Improvement of the design exploiting an accurate characterization of the physical structure of the filter (electromagnetic modeling). Extraction of equivalent circuits and coupling coefficients from EM simulation of coupled cavities. Outlines of smart optimization techniques (space mapping).