Utilizing Network Synthesis to Accelerate Matching Circuit Design

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Introduction

- The use of synthesis for matching networks can streamline design flows for a variety of RF and microwave applications:
  - High Power Amplifiers – including harmonic matching
  - Low Noise Amplifiers
  - Antenna Matching – including multiple bands.
  - Interstage Matching in Amplifiers
- Allows the designer to quickly explore a wide variety of matching network topologies
- Can work directly with load pull data in the case of power amplifiers (PAs)
- Very useful at the beginning of a design to determine reasonable performance targets (device sizing, decisions on active device periphery, performance limits, and more)
Synthesis Approach

- Recent advances in computer processing power and algorithms have made possible new approaches to matching network synthesis.
- More specifically, can evaluate ~10 million circuit responses per second on a modern PC.
- Uses a variant of genetic optimization as the underlying algorithm for parameter values.
- Has proven very effective for circuit design problems.
Search-Based Synthesis Engine

User decides which series and shunt elements to consider

Then, all possible topologies are explored by expanding the solution up the maximum number of user-defined matching sections
Heuristics are used to determine what can follow an existing element
• For example, a series TLIN can follow a series TLIN (for stepped impedance transmission lines)
• But, a series CAP cannot follow a series CAP

Practical considerations are also taken into account
• DC open and short paths
• Component limits and discrete values
• Impact of bias and feed networks
• Constraints on first/last elements in the network
Search-Based Synthesis Engine - 3

Solutions are sorted from best to worst as each expansion is added.

User has some control over the threshold for which solutions are considered for the following expansion (this allows tradeoffs between speed and search depth).
Search-Based Synthesis Engine - 4

Overall result is an extremely comprehensive search
Controlling the Search Space

The user can set:
- Component Types
- Elements in shunt and series
- Topology constraints (esp. 1\textsuperscript{st} and last elements)
- Number of Sections
Load-pull data can be used for the loads.

5 Ohm Smith Chart to see the contours better.
Load-Pull Example – Setting the Goals

- Goals are based directly on load pull data….that is to say, actual performance targets rather than impedance targets
- Can be based on sub-bands if necessary, rather than entire frequency band
Load-Pull Example – Other Goals

- Additional goals, which aren’t load pulled based, can also be added
- For example, a Smith Chart region target for 2nd or 3rd harmonics
Load Pull Example – Comparing Results

- At the end of the synthesis run, a user-defined number of candidate networks are generated.
- Easy to compare performance results of each network.
Additional Applications

- Direct conjugate matching
  - Useful for broadband and multiband antenna matching
- Inter-stage matching
  - Driver to Power Amplifier inter-stage match
  - Matching between two sets of complex impedances across frequency is often time consuming when done manually
- Noise match
  - For Low Noise Amplifier applications
  - Can be combined with other synthesis goals
- Smith chart impedance targets
  - Can also be used for fundamental frequency targets
Conclusions

- Matching Network Synthesis has been added to Microwave Office.
- A ladder-type filter is created using Genetically based synthesis algorithms.
  - They evaluate a large number of possibilities (computers are fast!)
- It works for matching any input and output loads:
  - PA matching – can use load-pull data. Harmonic load matching.
  - Antenna matching – multi-band match.