Passive Network Synthesis: Camelot in our Grasp

Prepared by

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King of the Engineering Art: the What?

- The Art of the Artificial!! What about Natural Philosophy?
- Synthesis!! What about Analysis?
- Prognostic!! What about Diagnostic?

Design: Dummy

Oh! Like in Passive Network Synthesis
Passive Network Synthesis

Aha! To Algorithmatize the Design Process! The Epitome of the Engineering Art!! Off with Your head.
What We Did!

- **1910s and 20s**
  - Developed Explicit Algorithms for Designing Passive LC Filters.
  - Established a Billion Dollar (in 1930s Dollars) Industry Designing Passive LC Telephone Filters.
  - Made Modern Telefony Possible!

- **1930s**
  - Passive Network Synthesis
  - Academic but it Taught us how to Handle Resistive Loads.
What Else We Did – Not Much

1940s
- Developed Explicit Algorithms for Designing Passive n-Ports
- Done Independently in 4 Countries During WWII
- Absolutely Beautiful – Totally Worthless

1950s – The Golden Age of Circuit Theory
- Didn’t do Anything Much, unless you count the Resistive n-port Problem – The Worlds Greatest Career Destroyer

1960s - Goodbye
What Happened?

- **Cheap Transistors**: When the price of a CK722 went from $99 to 99¢ in 6 Months
  - The Passivity Constraint Disappeared, and since *Design with Constraints is What Engineering is All About*, the Fun Disappeared Too!
  - Of Course, We hadn’t Discovered Sensitivity and Noise Floors Yet!
  - Since Our Company is at **WAR with Raytheon**, I Shouldn’t Admit that, as a High School Hobbyist, I Bought my First CK722 at **Allied Radio** when it Passed the $25 Threshold.
What Else Happened?

- **Expensive Computers:**
  When the Mainframe Replaced a Roomful of Graduate Students with Mechanical Calculators, **Engineering Art** was Replaced by **Brute Force**.

- **Passive Network Synthesis:** RIP
What’s This Have to do with Camelot?
And What Do You Think You Guys are Going to Do Out There?

Adaptive Control

Active Synthesis?

Youla Parameterization

H_\infty Control

Diaspora
Let $P = ND^{-1}$, where $N$ and $D$ are Stable and Coprime, i.e., there exist Stable $U$ and $V$ such that; $UN + VD = 1$.

Then the set of all possible Stabilizing Feedback Gains may be Parameterized by

$$F = [DW+U][NW+V]^{-1}$$

where $W$ is Stable.
What Did Dan Do?

NO, He didn’t Algorithmatize the Solution of All Linear Control Problems

BUT, He Did Parameterize the Constraint Set

The Solution of “Most” Linear Control Problems Follows From the Youla Parameterization.

- $H_2$ and $H_\infty$ Optimal Control,
- Tracking and Disturbance Rejection
- Pole and Zero Placement
- Robust Control and Simultaneous Design
Why not Learn the Design?

- Just Design a **Generic Control Architecture** or Two and let it **Learn the Design in Real Time**
- The Trick is to use **Measurements of the Actual System** in Operation instead of a Model of the System
- This Algorithmatizes the Design Process and Yields an **Adaptive Controller** which Compensates for - **System Failures** and **Environmental Changes**

Accurate Automation Corporation

It’ll Never Work!!

Yes it Will
Two Adaptive Control Algorithms

- Neural Adaptive (Tracking) Controller
- Adaptive Dynamic Programming (Optimal) Controller

- Both Algorithms are:
  - Nonlinear
  - MIMO
  - Require “Minimal” *a priori* Knowledge About Plant
  - Characterized by a Full Stability Theory
LoFLYTE® Adaptive Dynamic Programming

Vertical Component

Elevator Deflection
LoFLYTE® Neural Adaptive Control

Compensated, 100 kts, 1500 ft
Three Axes Commanded

Uncompensated, 100 kts, 1500 ft
Three Axes Commanded
Destabilization (CG from 51% to 56% at 6s)
The Real Thing!!

LoFLYTE® at Edwards AFB
Electric Vehicle Control
HEV Performance

If 1 is Good, 4 is Better!

Lightly Loaded HEV
On Icy Patch

Heavily Loaded HEV
On Dry Road
Unmanned Surface Vessel

- Turned on controller
- Boat traveling in clockwise direction
- Controller hits every way-point every time (<16 foot tolerance)
- 800 feet legs
Why Not Launch a UAV from a USV?
Off with His Head!!