

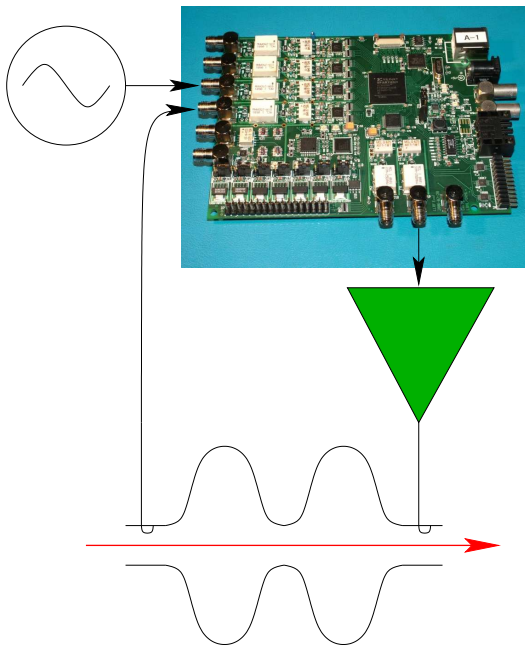
# Low-level RF Control System Design and Architecture

Lawrence R. Doolittle, LBNL, Berkeley, CA 94720, USA

APAC 2007, session 7 'Accelerator Technology'  
RRCAT, Indore, India, Jan 28 - Feb 2, 2007

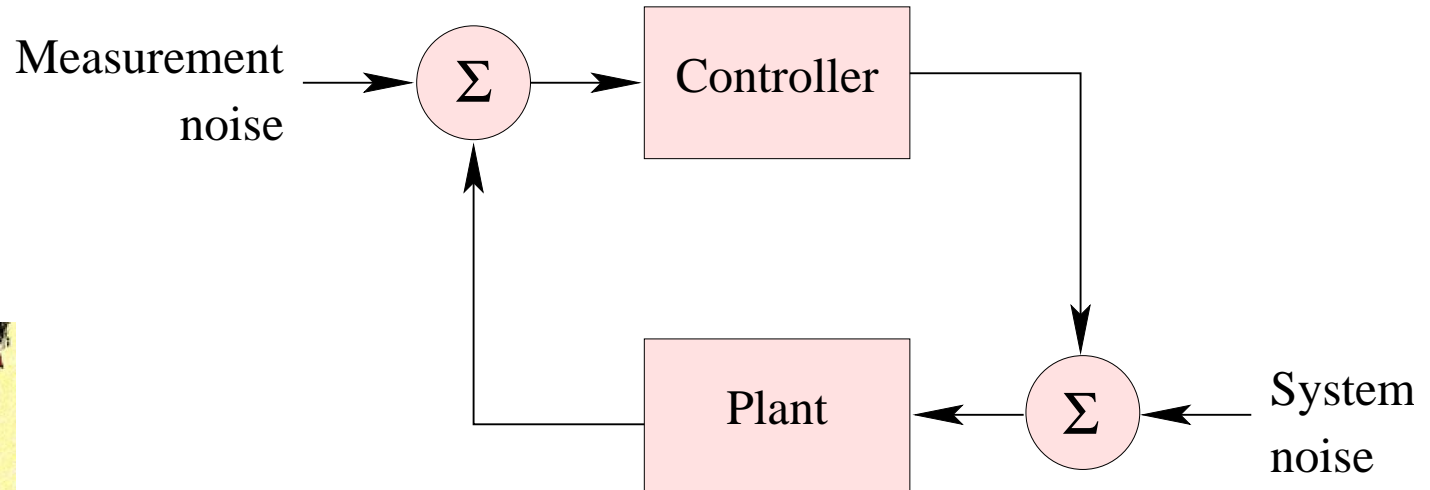


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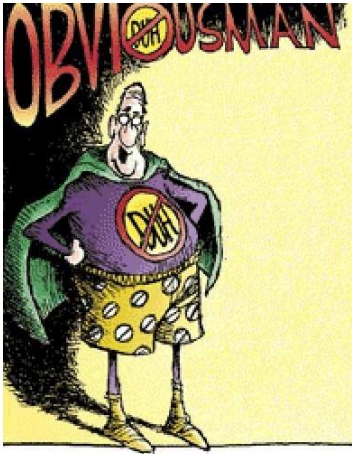


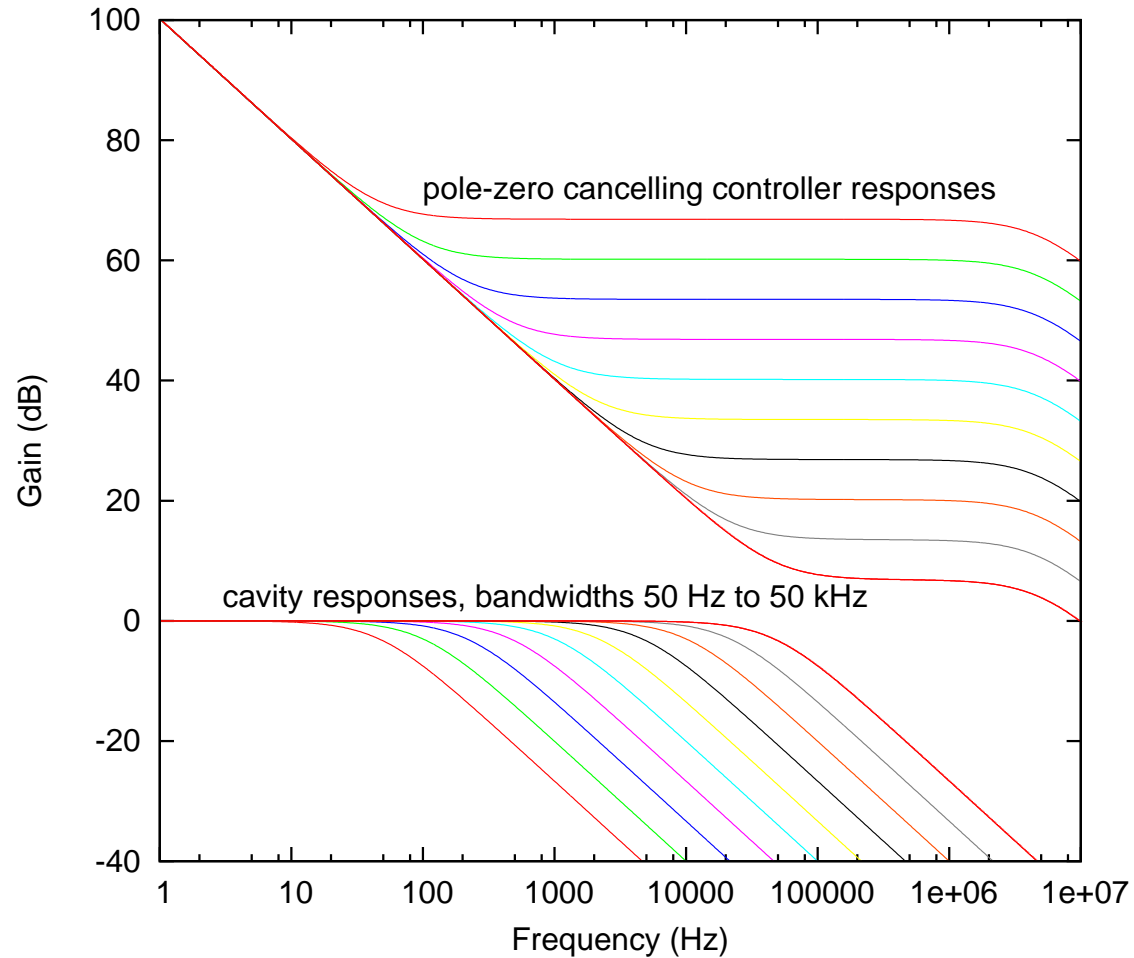
Problems worthy of attack  
show their worth by hitting back.  
-Piet Hein (1905-1996), Danish polymath

# Analog, Digital, or Hybrid



single or multiple cavities  
normal or superconducting  
pulsed or CW  
ring or linac

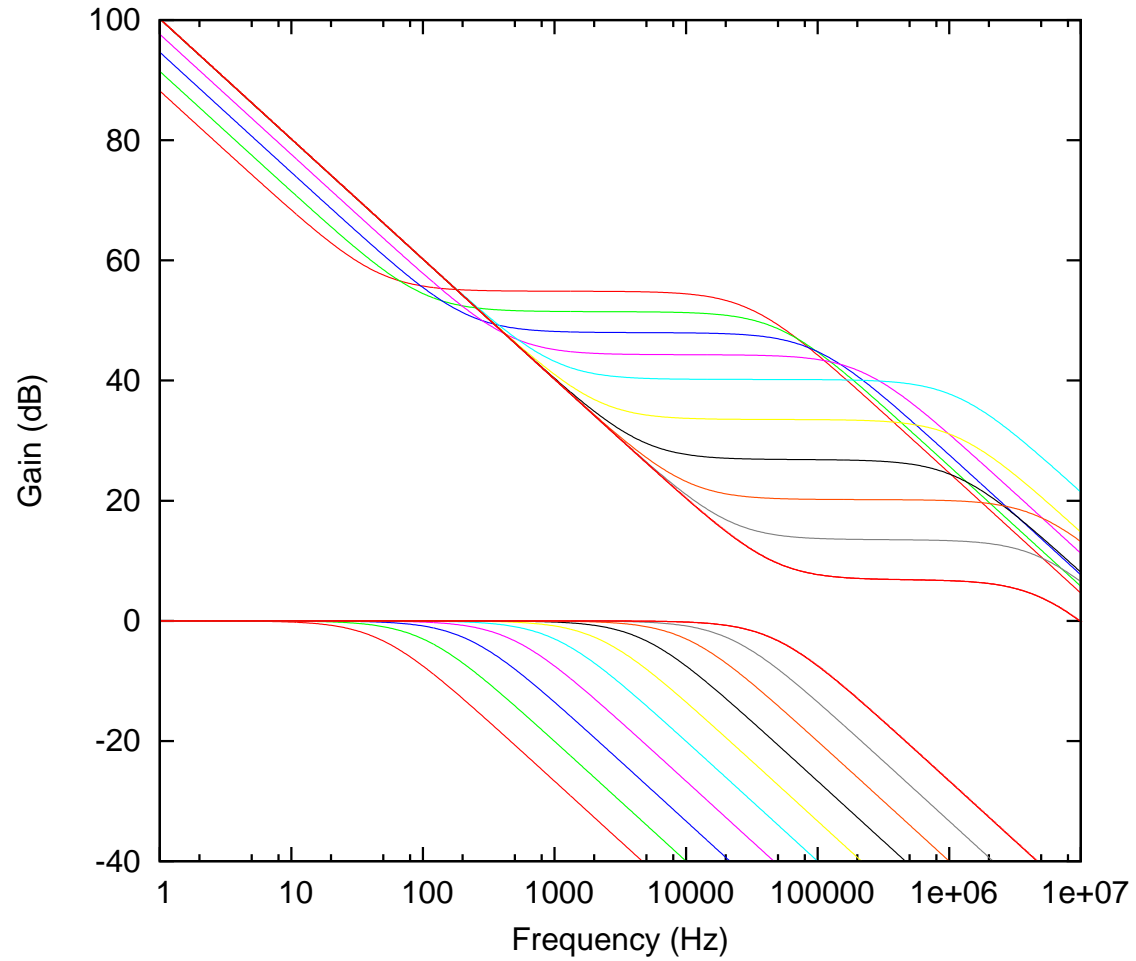




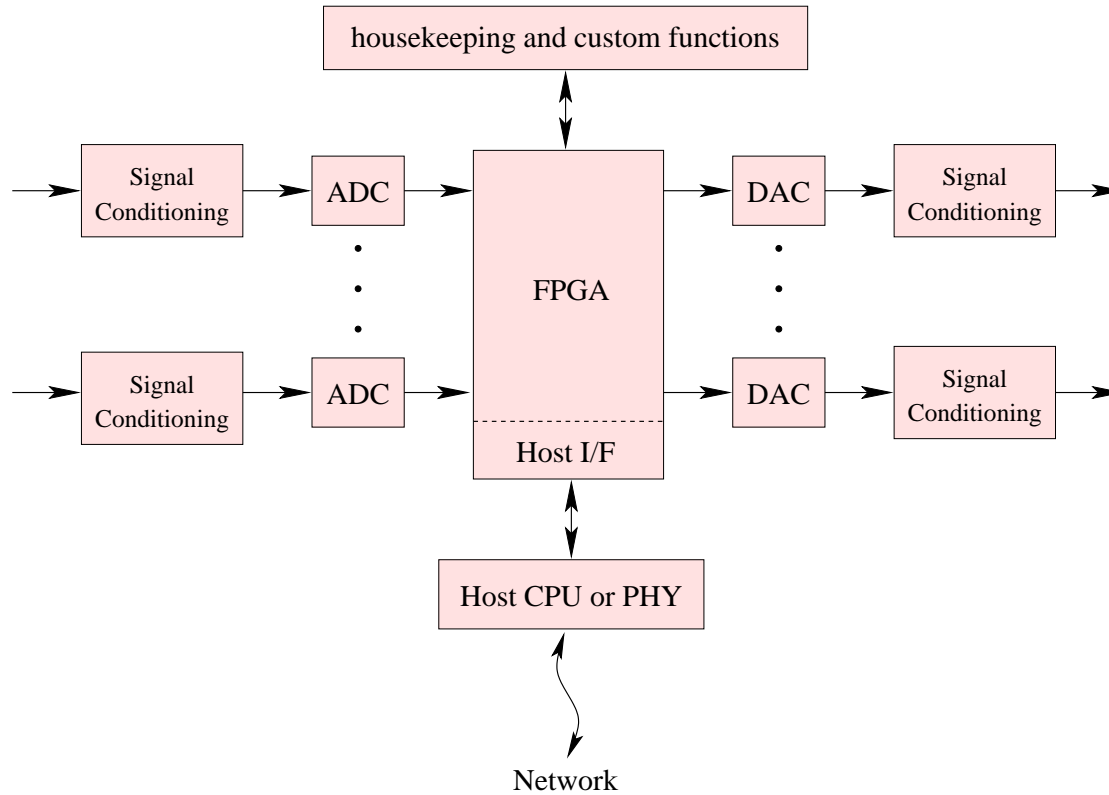
$$\text{Gain} = K_P + \frac{K_I}{s}$$

A complex system that works is invariably found to have evolved from a simple system that worked.

- John Gall, U.S. author



$$\text{Gain} = \frac{K_P}{1 + s\tau} + \frac{K_I}{s}$$

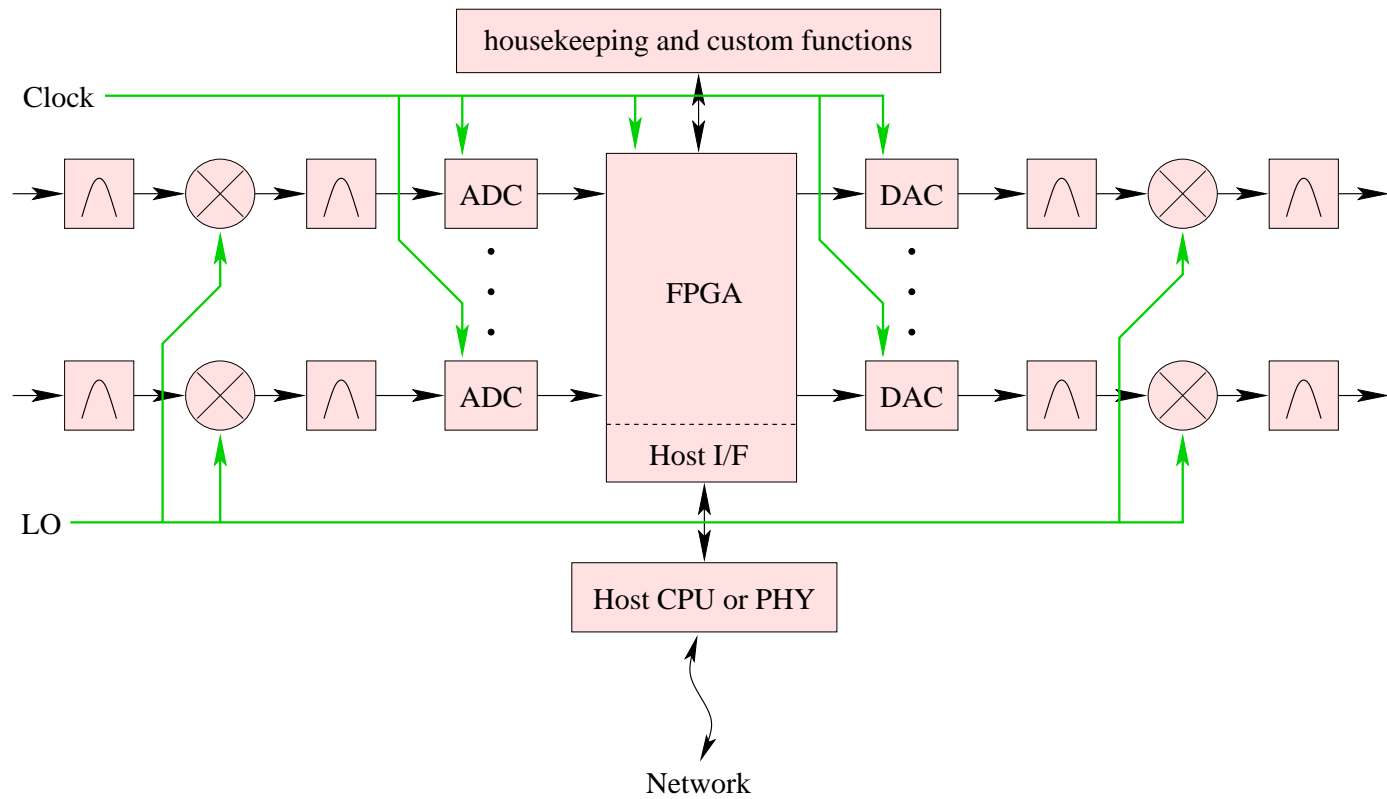


The cheapest, fastest and most reliable components of a computer system are those that aren't there.  
 - Gordon Bell (1934-), U.S. computer engineer



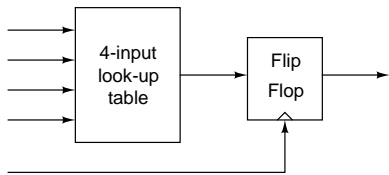
Embrace simplicity.  
 Put others first.  
 Desire little.  
 - Laozi (4th century BC?), Chinese philosopher

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## Computer      FPGA

Programmable digital logic device	Yes	Yes
Major suppliers	uncountable	2
Glue-less hookup to most DAQ hardware	-	Yes
Guaranteed low-latency processing	-	Yes
Good programming languages	Yes	-
Good programming requires thought and experience	Yes	Yes



1536 (US\$10) to 178176 (US\$6000) cells,  
plus routing, carry chains, multipliers, RAM, input, and output

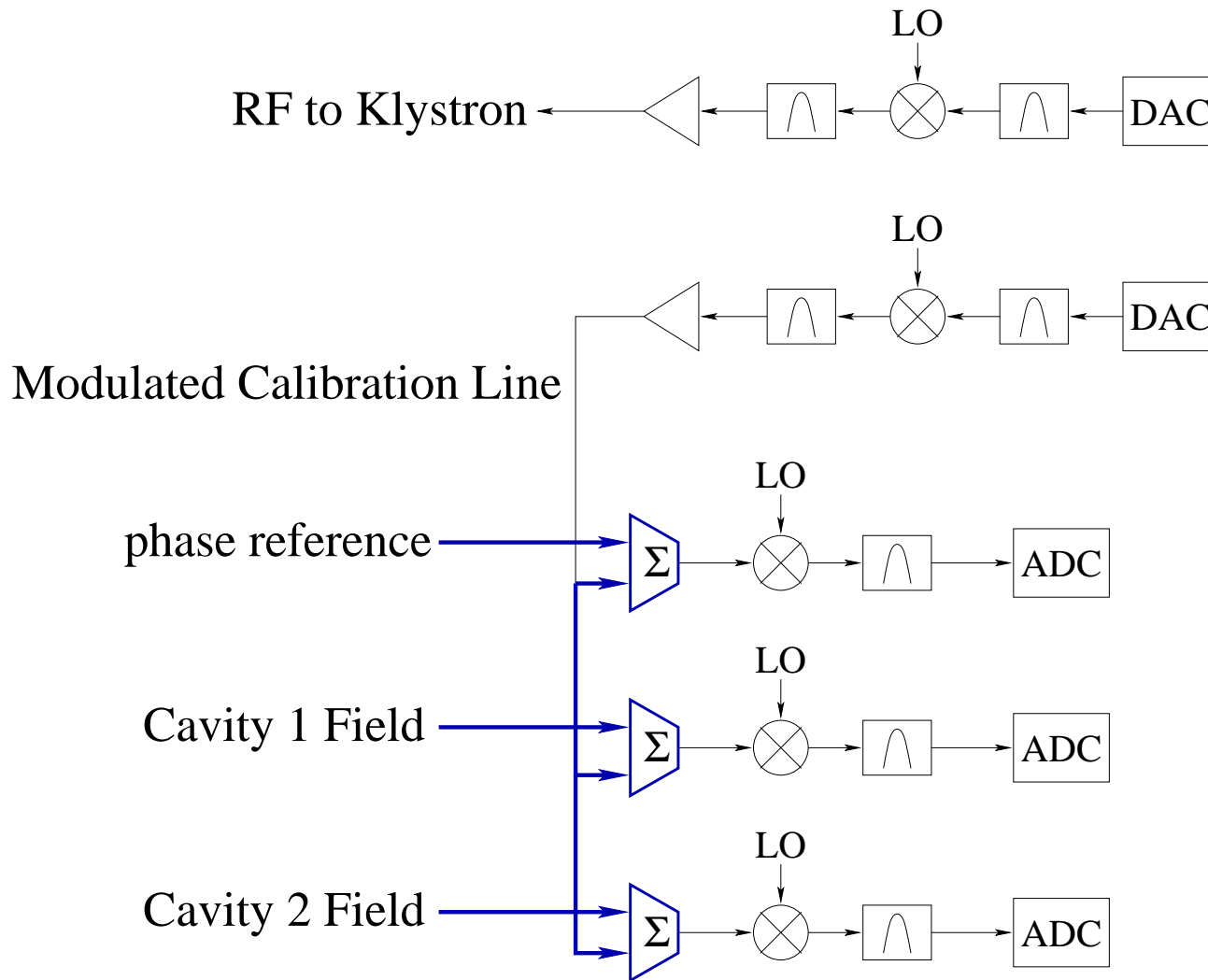
VHDL was written by a bunch of software guys who knew nothing about designing hardware.  
We beat on it until you could do hardware with it.  
Verilog was written by a bunch of hardware guys who knew nothing about designing software.  
We beat on it until you could do software with it.  
Neither does the job they were originally intended to do, but they work.

- David Bishop, Engineer



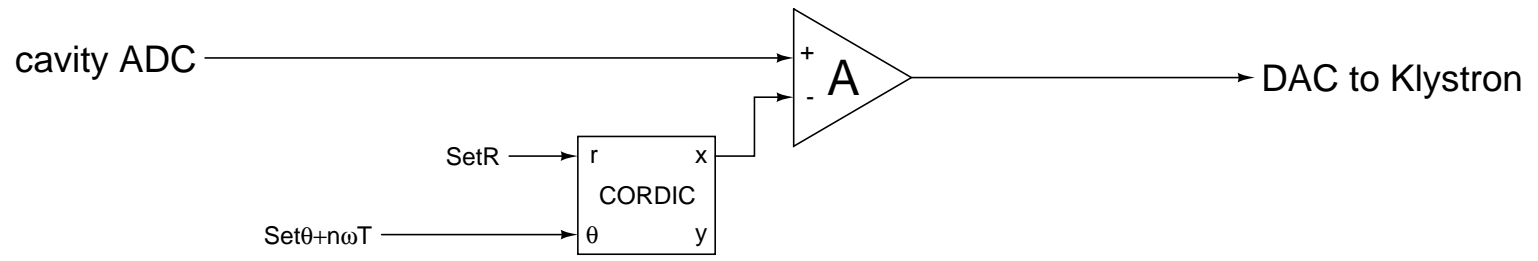
When someone says 'I want a programming language in which I need only say what I wish done,' give him a lollipop.

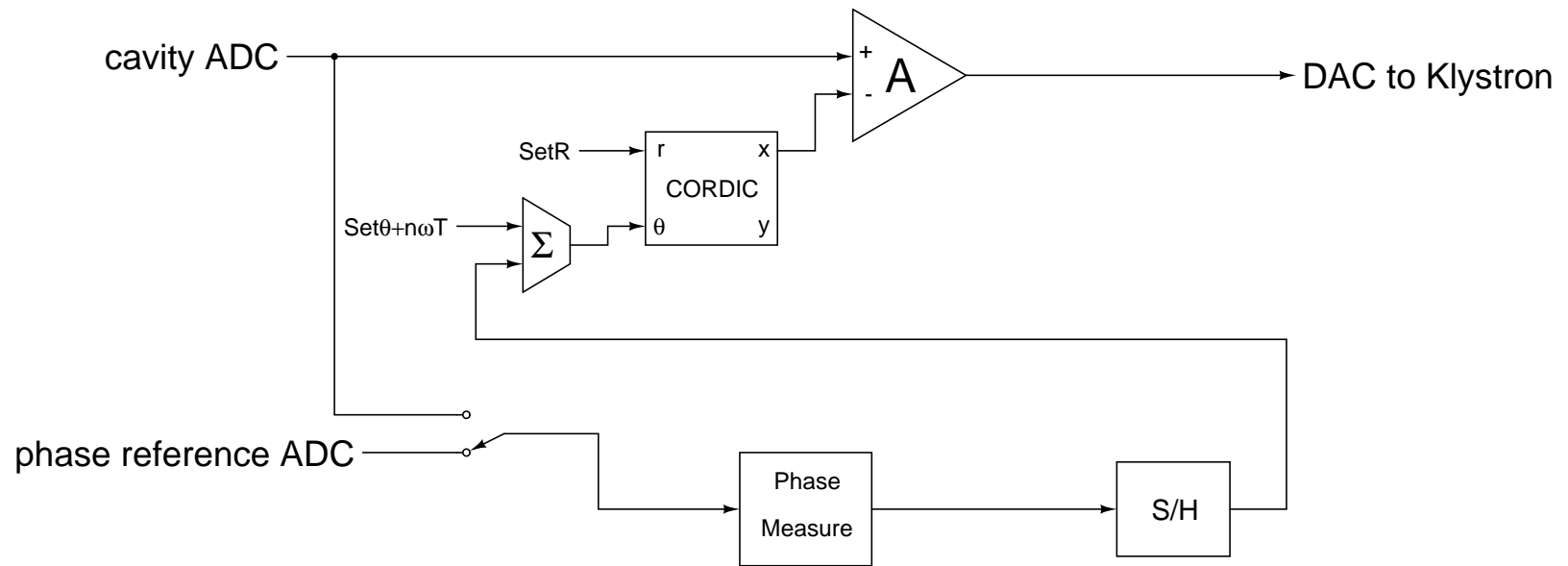
- Alan Perlis (1922-1990), U.S. computer scientist

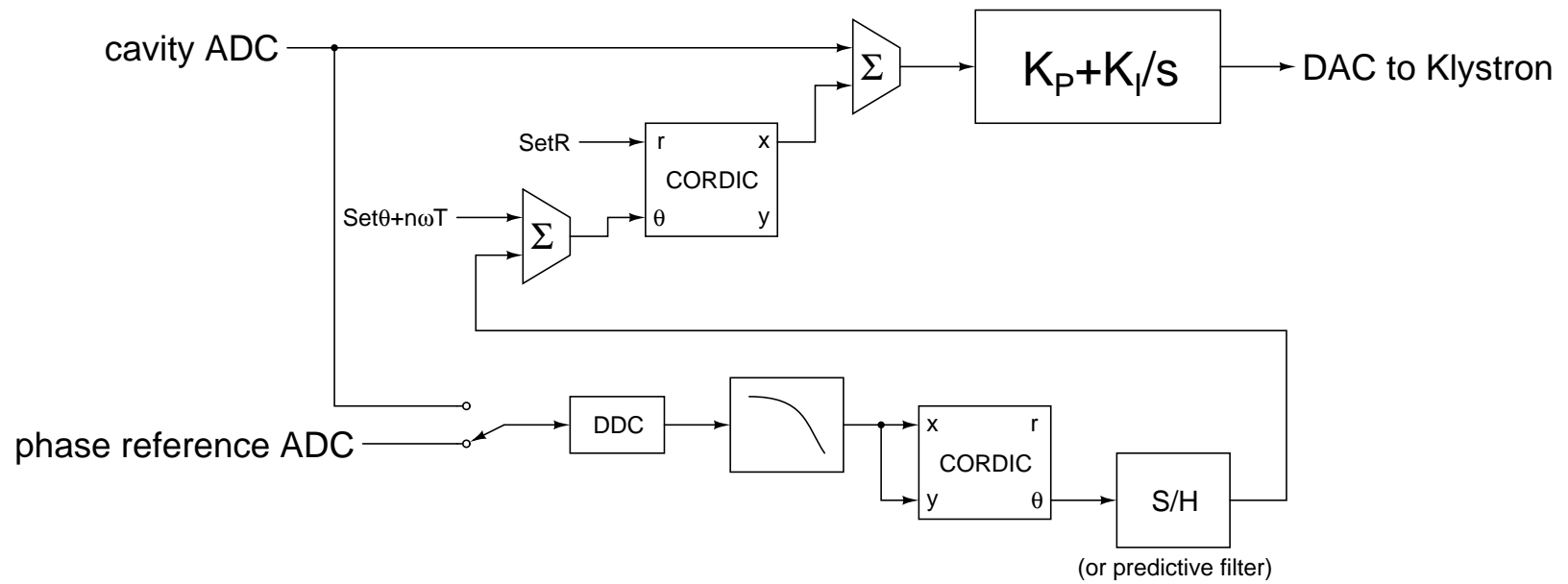


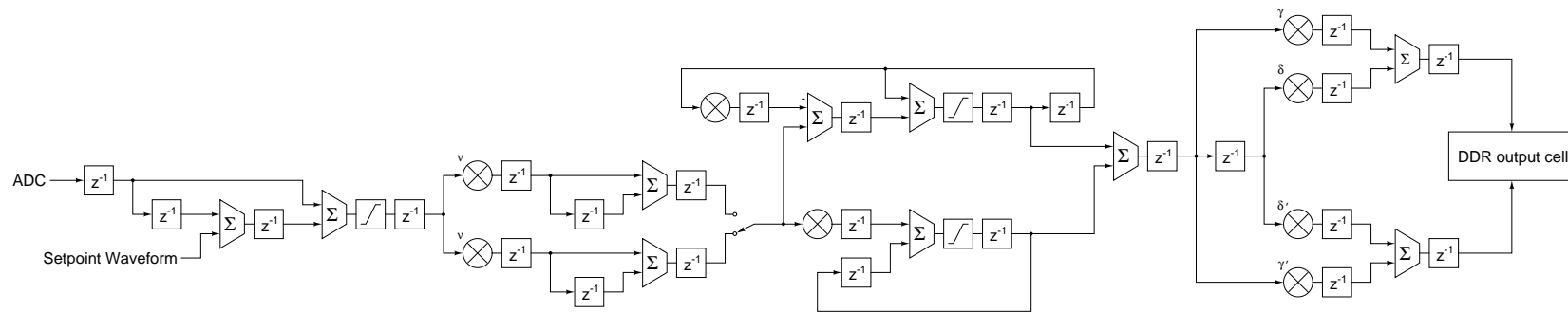
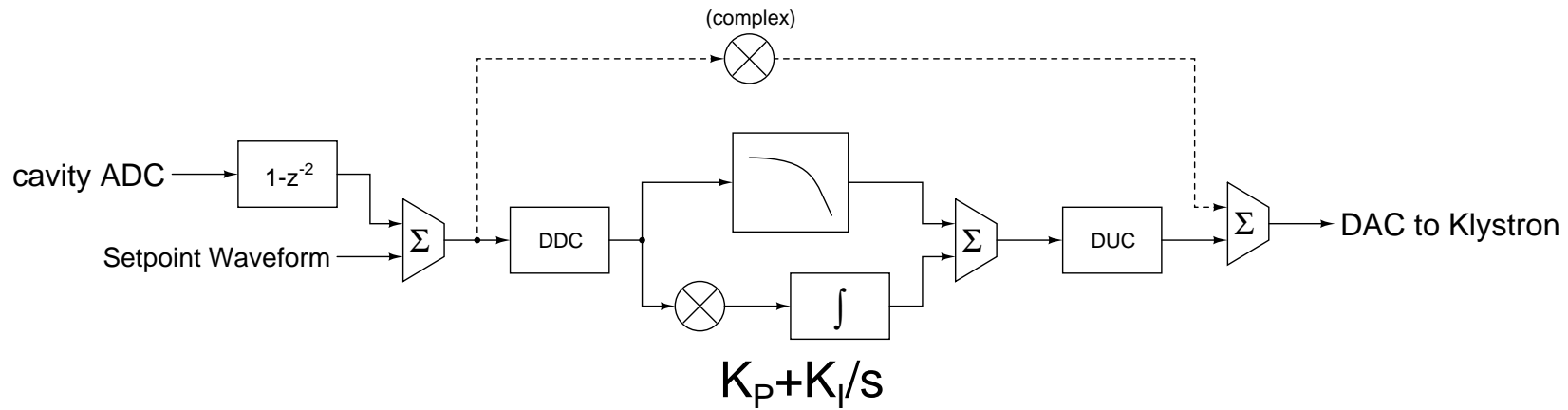
Be patient, man. I'm trying to be linear.  
 -A.L.F., fictional TV alien, 1986-1990









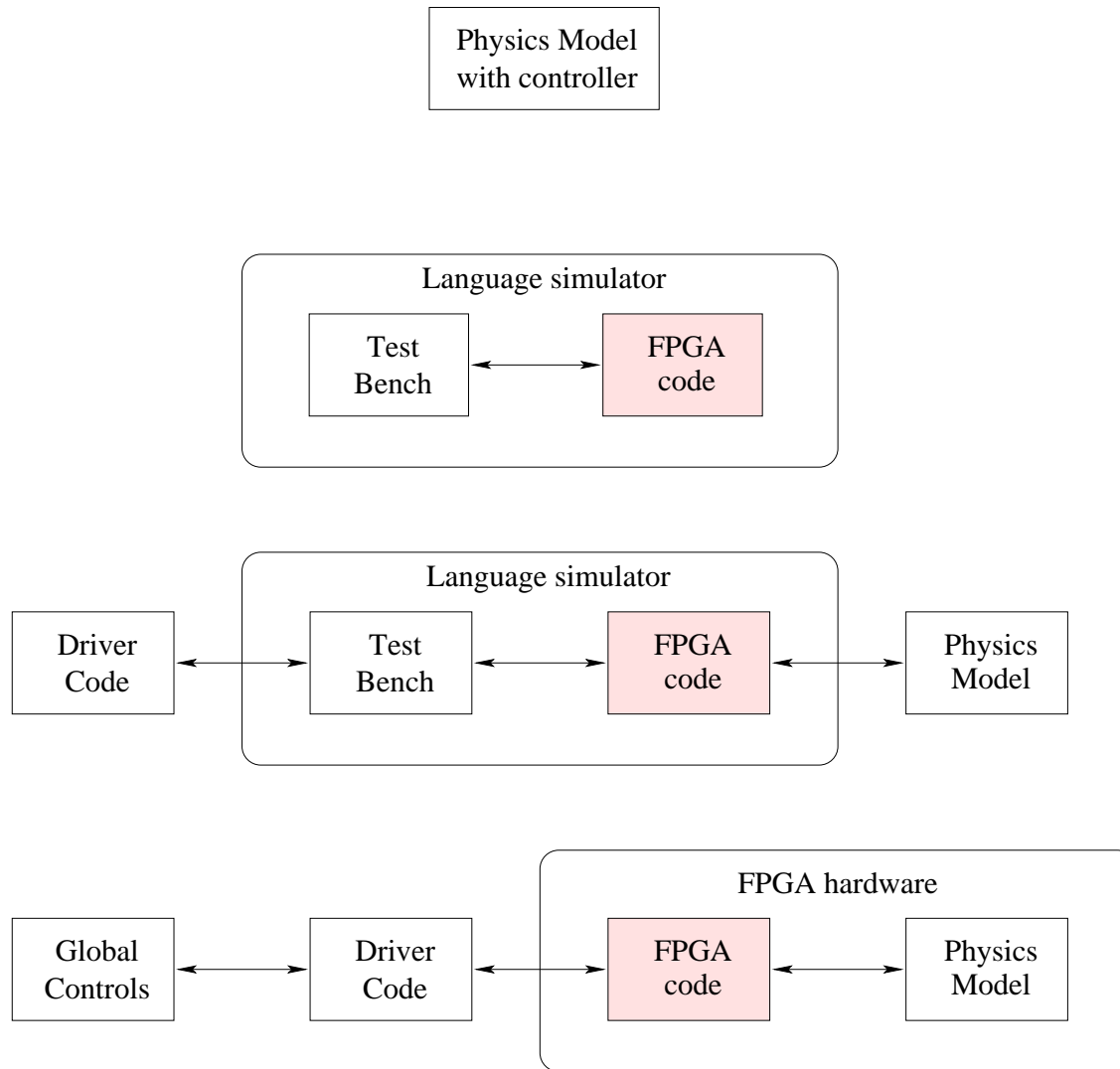


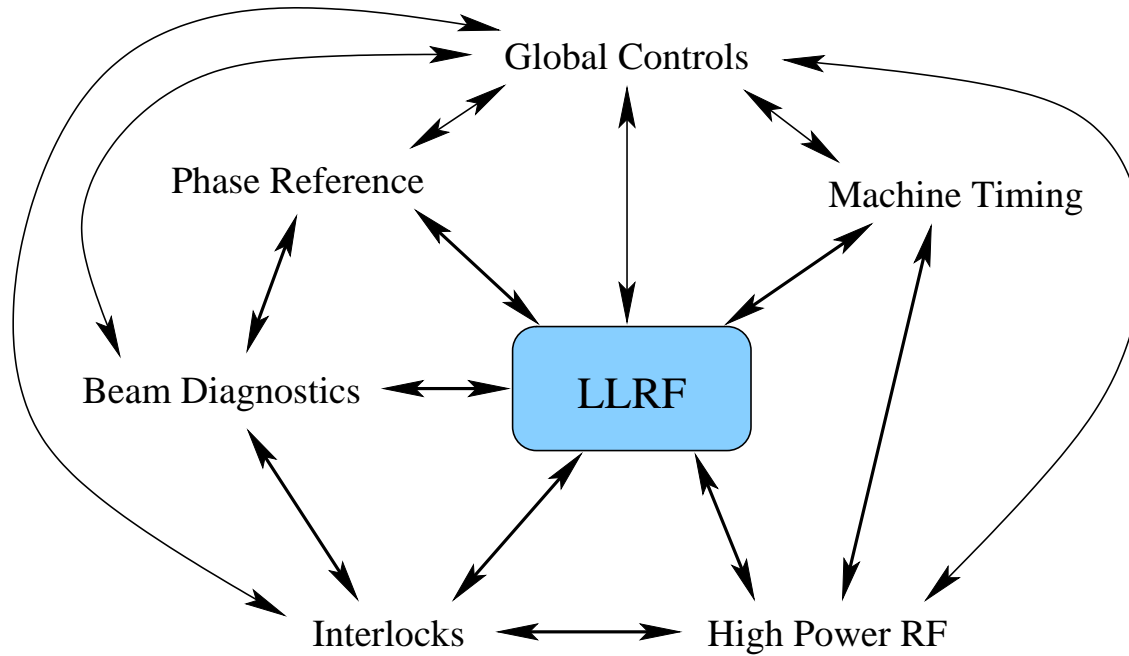
What's the difference between hardware and software?

Hardware keeps getting cheaper, faster, and smaller.

- Rick Cochran, U.S. system analyst

# Simulations





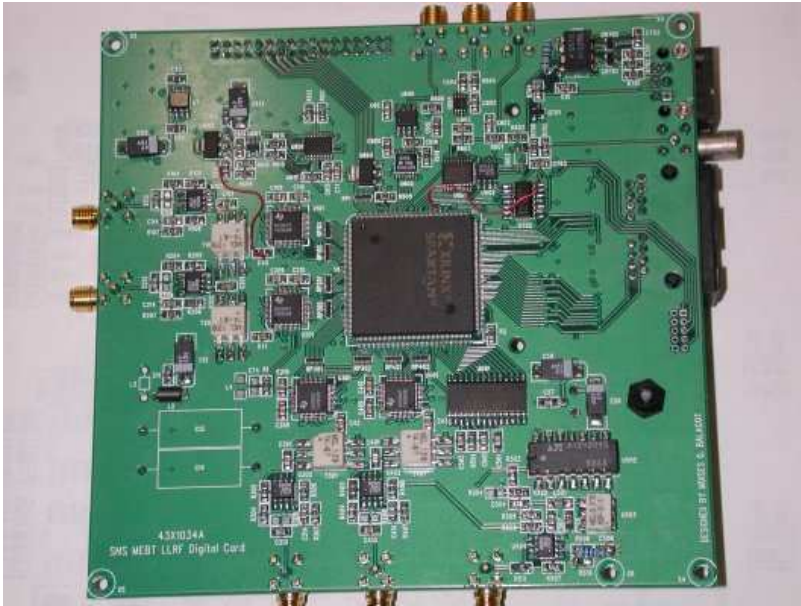
Additional mandatory features:

- cavity detune measurement
- self-test, self-cal
- exception handling

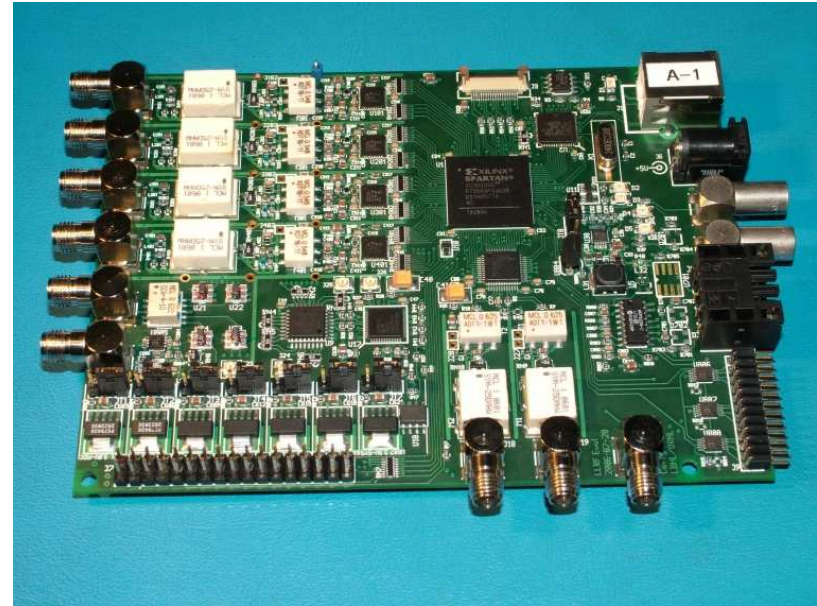
It is easier to move a problem around than it is to solve it.

- Ross Callon, U.S. network engineer

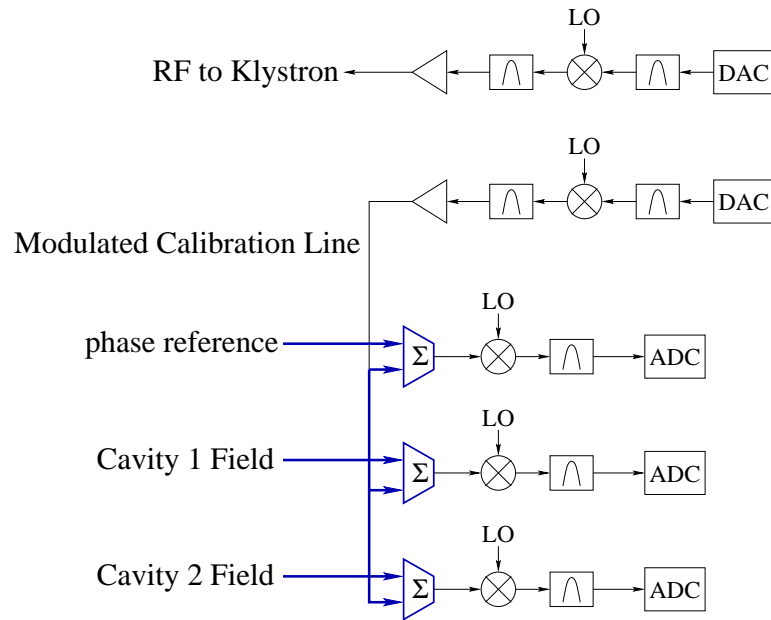
2001



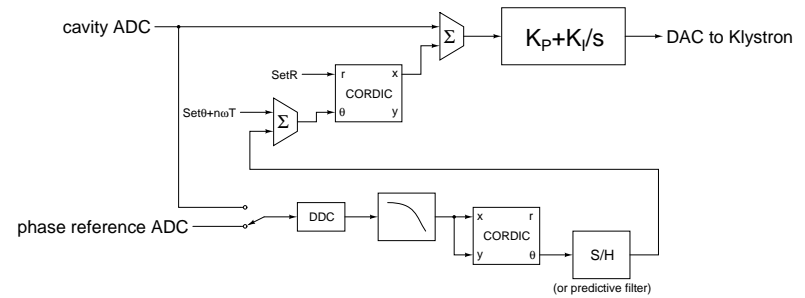
2006



# Hardware



# Software



Perfection is achieved, not when there is nothing more to add, but when there is nothing left to take away.

-Antoine de Saint-Exupéry (1900-1944), French writer and aviator



Thank you for your attention!

धन्यवाद

## Acknowledgments

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Stefan Simrock	John Staples
Yubin Zhao	

Image credits: Wikipedia, Wiley Miller

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I have only made this letter rather long because I have not had time to make it shorter.

- Blaise Pascal (1623-1662), French mathematician and philosopher