

Inter/Multi-Disciplinary Engineering: Education and Research

EE Happy Hour! 😊
Nov. 2009

Prepared by:
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Scope

- Definitions
- Education: Worldwide, Middle East
- Research
- Personal Research
 - Signal Integrity
 - Embedded Systems
 - RF Electronics and Antenna Arrays
- Closing Remarks

Definitions

- An **interdisciplinary field** or **multidisciplinary field** is a field of study that crosses traditional boundaries between academic disciplines or schools of thought, as new needs and professions have emerged.
- An **interdisciplinary** community or project is made up of people from multiple disciplines and professions who are engaged in creating and applying new knowledge as they work together as equal stakeholders in addressing a common challenge. The key question is what new knowledge (of an academic discipline nature), which is outside the existing disciplines, is required to address the challenge.
- A **multidisciplinary** community or project is made up of people from different disciplines and professions who are engaged in working together as equal stakeholders in addressing a common challenge. The key question is how well can the challenge be decomposed into nearly separable subparts, and then addressed via the distributed knowledge in the community or project team.

[*] Wikipedia.com

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Why MDE?

“The national landscape of engineering is changing. Fast-moving, global, multidisciplinary environments require graduates to have not only the traditional technical knowledge of their predecessors, but also a new and broader skill set. Engineers must now understand and apply several disciplines to solve complex problems, adapt to new technology and rapidly changing situations, combine ideas to synthesize creative solutions, and work effectively on teams using excellent communication skills. ”

Inter/Multi-disciplinary

- Combination of EE, ME and CE
- Emphasizing the Design, Built, Test methodology
- Emphasizing the project-based learning concept (capstone)
- Team Work!
 - Spend Several semesters to complete a real world project
 - Usually added as a minor to the degree.

Some Universities

- University of Michigan (USA): Multidisciplinary Design Program
 - Purdue University (USA): Inter/Multi-disciplinary Engineering Program [ABET accredited 2008]
 - University of Notre Dame (USA): capstone project in Multidisciplinary Engineering
 - Baylor University (USA): Multidisciplinary Engineering
- IEEE Multidisciplinary Education Magazine

Arab World!

- Jobs are usually multi-disciplinary in nature
- Most engineering openings focus on maintenance and service (or even sales!)
- Focus on one area is not appreciated, rather a wide range of experience (job type?, employer?)

⇒ MDE? Maybe!

→ Multidisciplinary Engineering

Arab World cont.

- Research in the Arab world is also of multidisciplinary nature
- Oil, Water, Gas ...
- Collaboration with other Engineering and Natural sciences is a must!
- Exposure to some of these sciences early on will be beneficial!

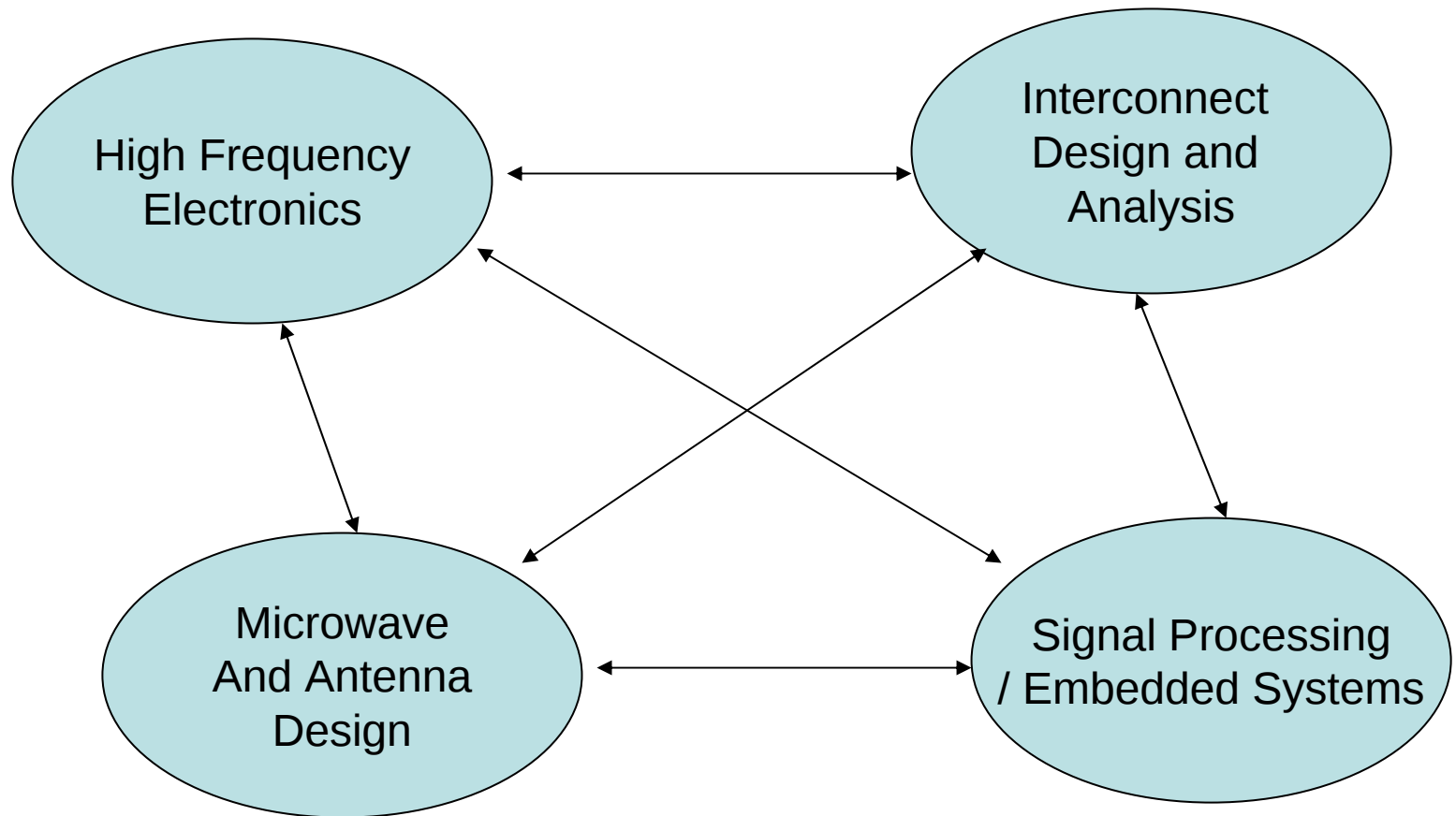
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Some Research Areas/Projects

- System level research and projects usually are of multi/inter-disciplinary nature
- Most of the real life systems/products contains mechanical, electrical (computer) as well as other natural science concepts
- MDE is usually performed in an indirect way in these projects (a team will consists of several engineers, some are EEs, MEs, CEs, physicists, etc...)

Inter-disciplinary frame work



A. Signal Integrity

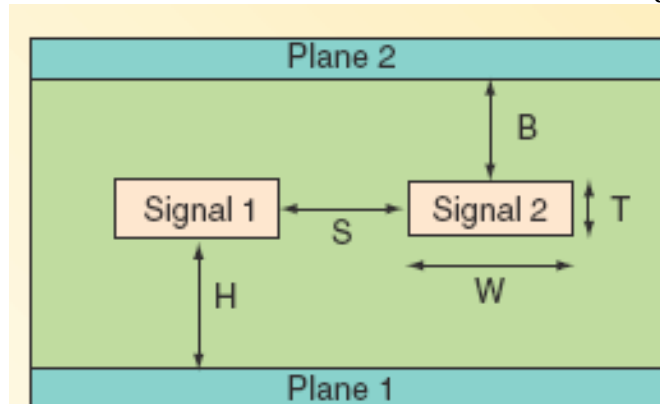
- Before starting:
My boss as a Signal Integrity Design Engineer in SGI had a Masters in Physics!
- SI is a rather new discipline in EE and CE where the design engineer has to perform a whole set of verification and modeling of the high speed channel (busses + drivers and receivers) to insure that the degradation due to channel imperfections will not jeopardize system performance.
- SI is a combination of digital, analog and electromagnetic field theory, all being utilized to identify any system performance and signal degradation issues.
- Careful modeling and design is extremely important, and testing and simulation should include all operating corners of the design.

Interconnect Modeling

- Stripline:

$$Z_0 = \frac{60}{\sqrt{\epsilon_r}} \ln \left(\frac{4(H+B)}{0.67\pi(T+0.8W)} \right)$$

$$T_{PD} = \frac{\sqrt{\epsilon_r}}{c}$$



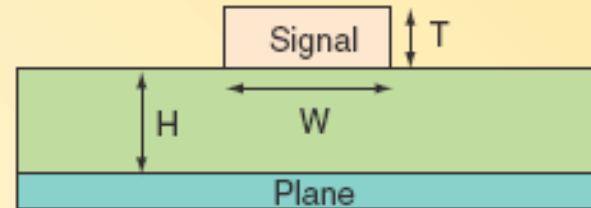
(a) Stripline

- Microstrip:

$$Z_0 = \frac{87}{\sqrt{\epsilon_r + 1.41}} \ln \left(\frac{5.98H}{(T + 0.8W)} \right)$$

$$T_{PD} = \frac{\sqrt{\epsilon_e}}{c}$$

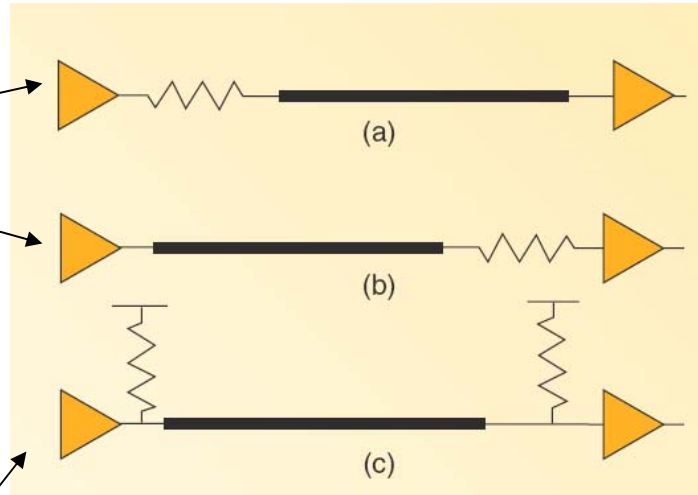
$$\epsilon_e = \frac{\epsilon_r + 1}{2} + \left[\frac{\epsilon_r - 1}{2} \right] \left[1 + \frac{12H}{W} \right]^{-1/2}$$



(b) Microstrip

Impedance Matching and Trace Resistance

Series Termination
(CMOS, LVTTTL)

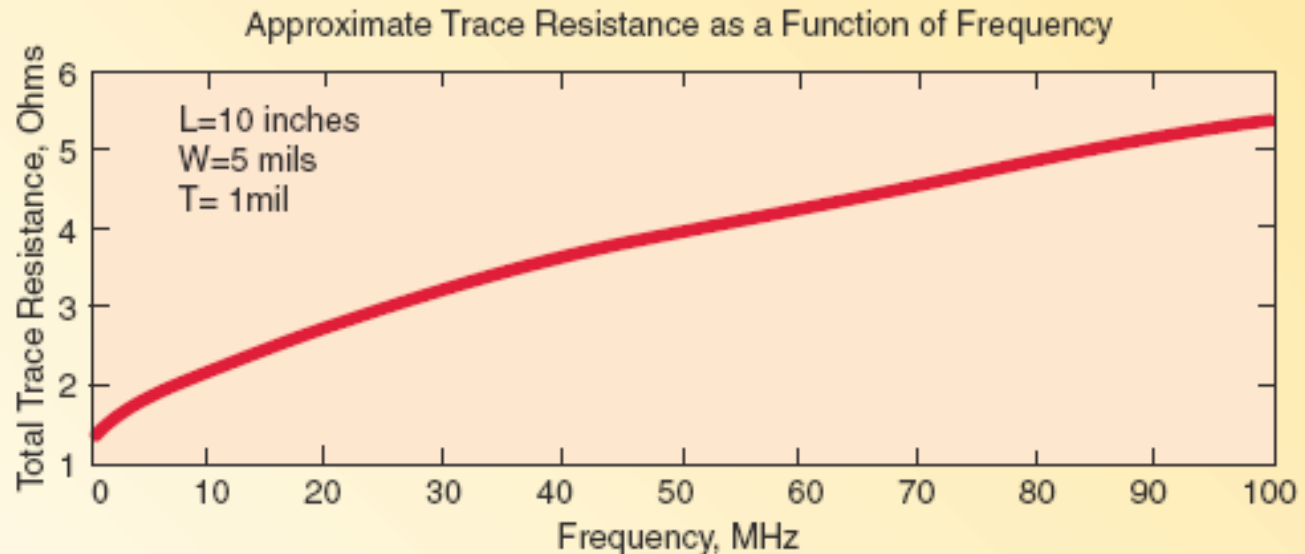


Parallel Termination
(SSTL, HSTL)

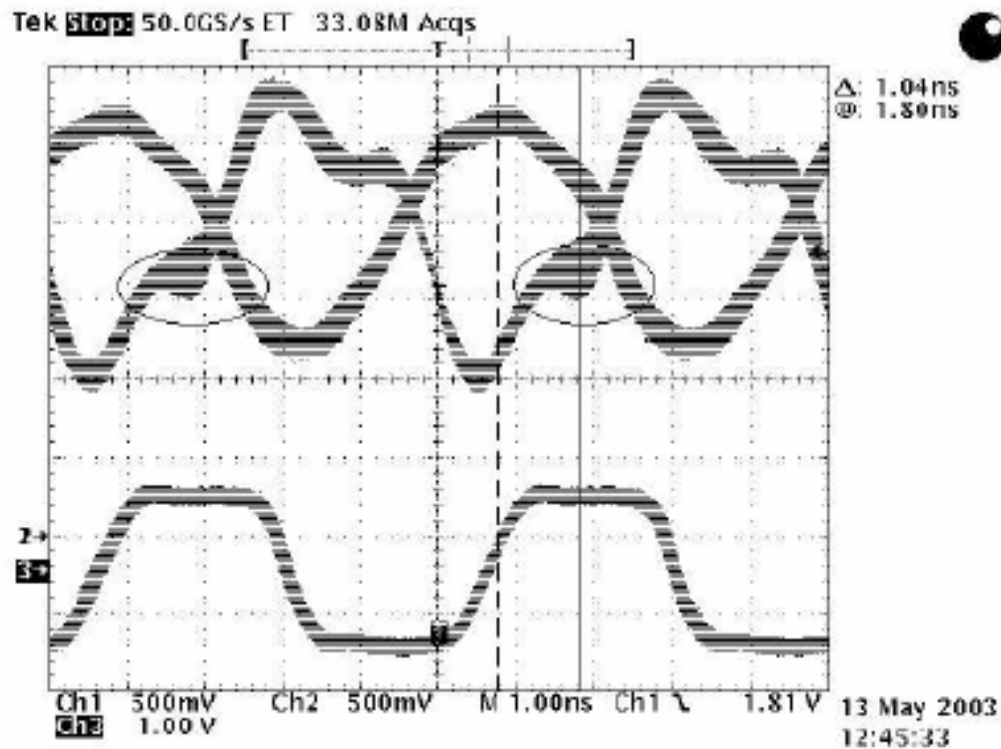
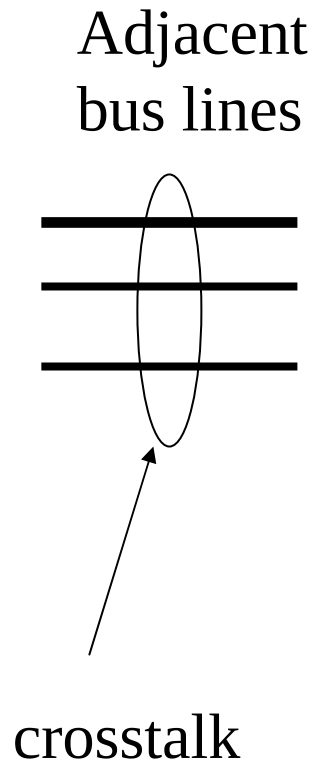
$$R_{DC} = \frac{\rho L}{WT}$$

$$R_{AC}(f) \approx \sqrt{\frac{\rho \pi \mu f}{W}}$$

$$R_{TOTAL}(f) = \sqrt{(R_{DC})^2 + (R_{AC})^2}$$



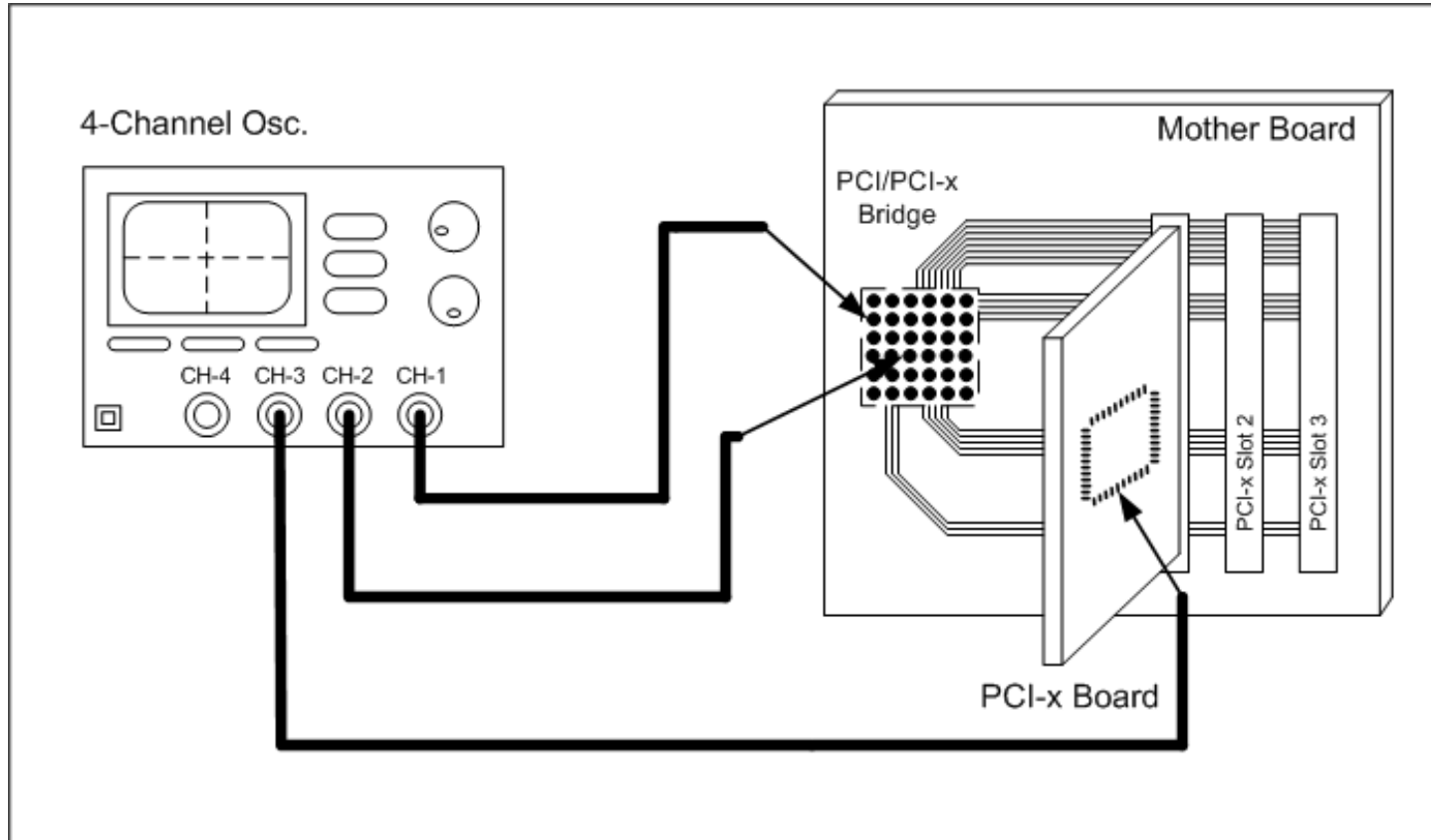
Crosstalk



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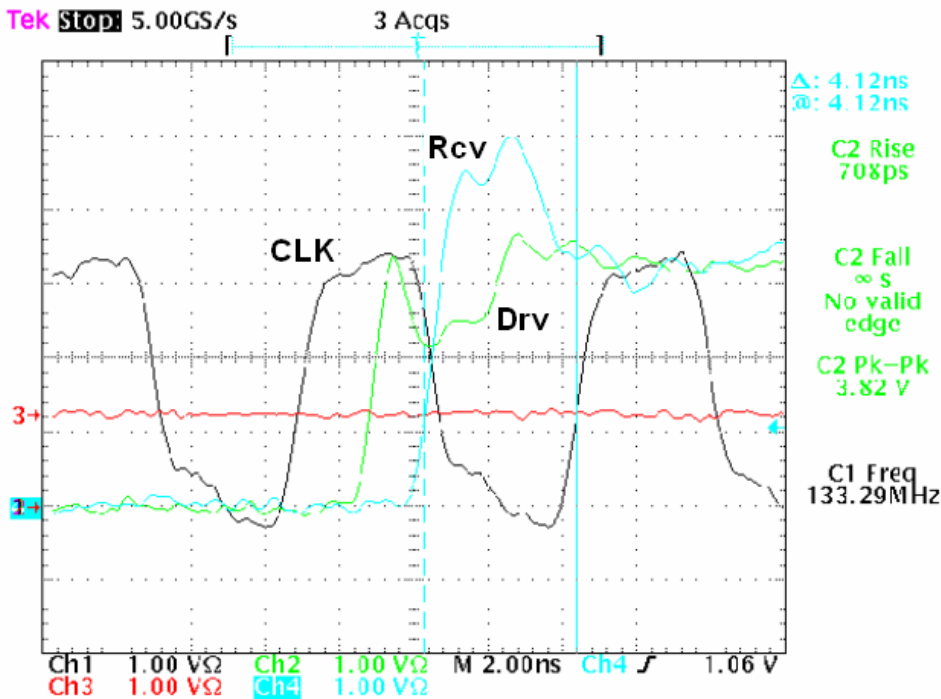
400MHz PECL clock signal. (Measurement)

PCI-x 66/133 MHz

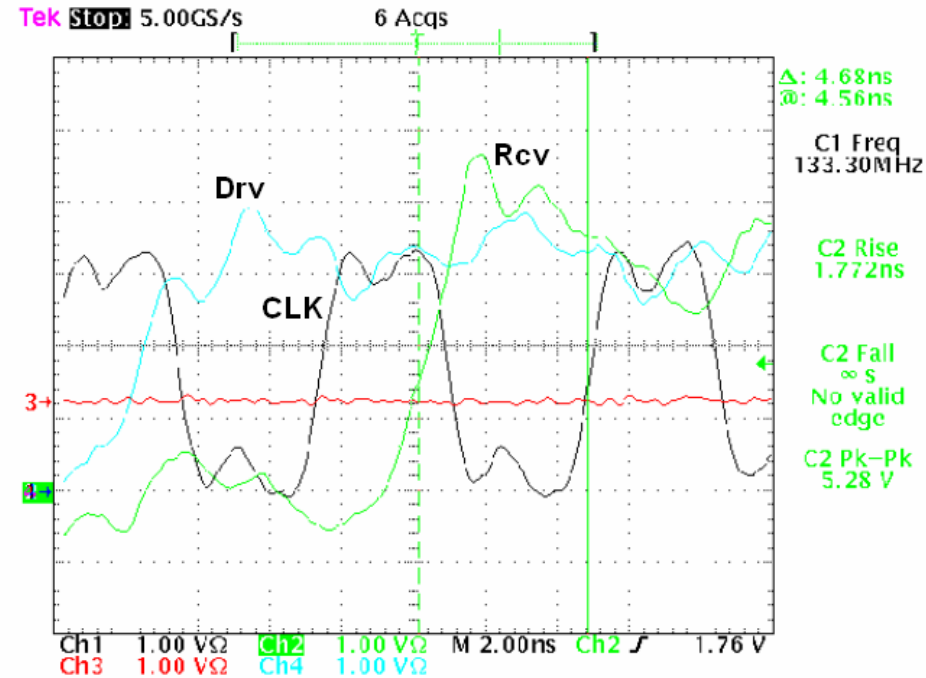


Signal integrity characterization setup for the PCI/PCI-x bus.

PCI-x 133 MHz



Measurement, PCI-x bridge chip driving the loaded card, 133 MHz operation.



Measurement, PCI-x loaded card driving the bridge chip, 133 MHz operation.

[2] M. S. Sharawi, "Signal Integrity Characterization and Modeling of a PCI/PCI-x 66/133 MHz bus," IEEE MWSCS 2008.

In SI ...

- Interconnect Modeling/Design
- Signaling types
- PCB Design
- Jitter Analysis
- Noise Analysis
- Equalization
- Serializer /DeSerializer
- Error-Correction

B. Embedded Systems

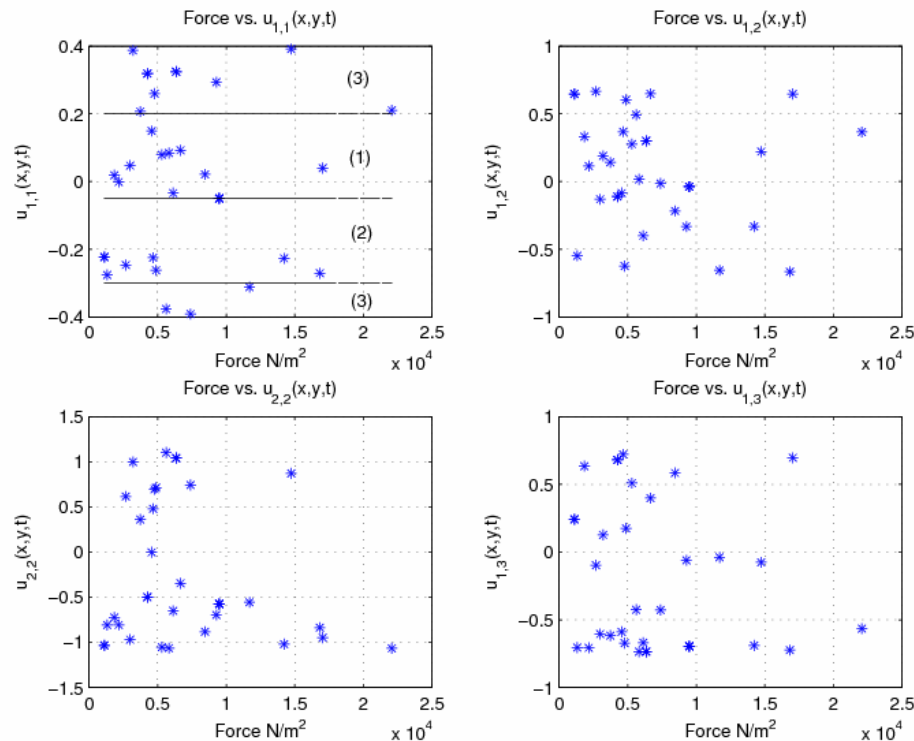
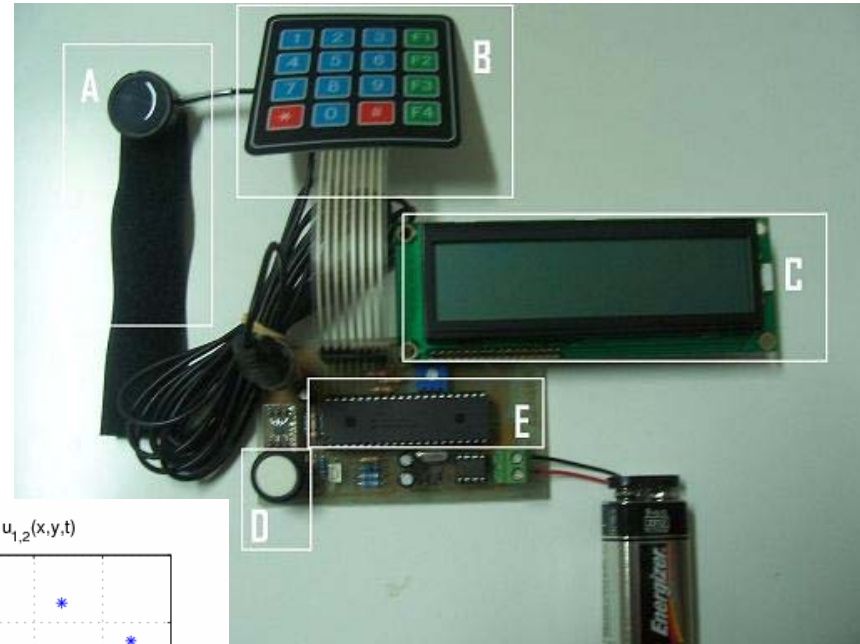
- I) Human Stress Detection System:
- Develop a PDE model and solution
 - Come up with sensory circuits and their integration
 - Come up with a microcontroller based program to implement the PDE solution
 - Details are not mentioned here refer to [1,2].

[3] M. S. Sharawi, et. al., "Design and Implementation of a Human Stress Detection System: A Biomechanics Approach," IEEE ISMA 2008.

[4] M. Shibli and M. S. Sharawi, "Modeling and Characterization of a Mechatronics Systems for Human Stress Detection," IEEE ICSCP 2007.

HSDS implementation

- The overall system success rate in identifying one of three states (relaxed, half stressed and stressed) was 60% and 78% for detecting stressed people based on a simple classification rule.
- Can be used for detecting drowsy drivers on roads!

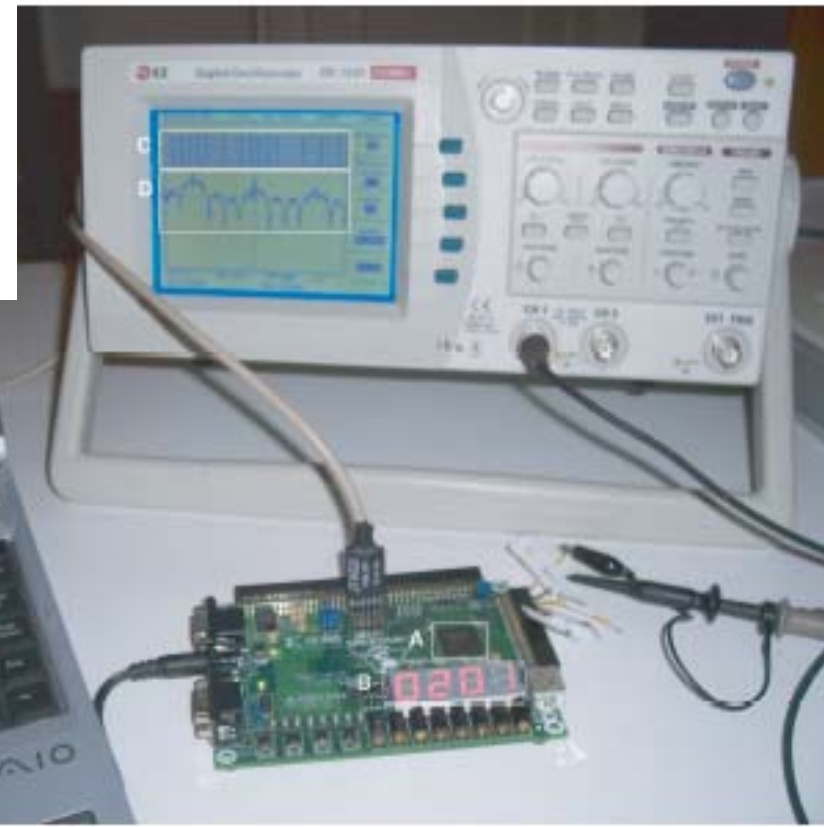
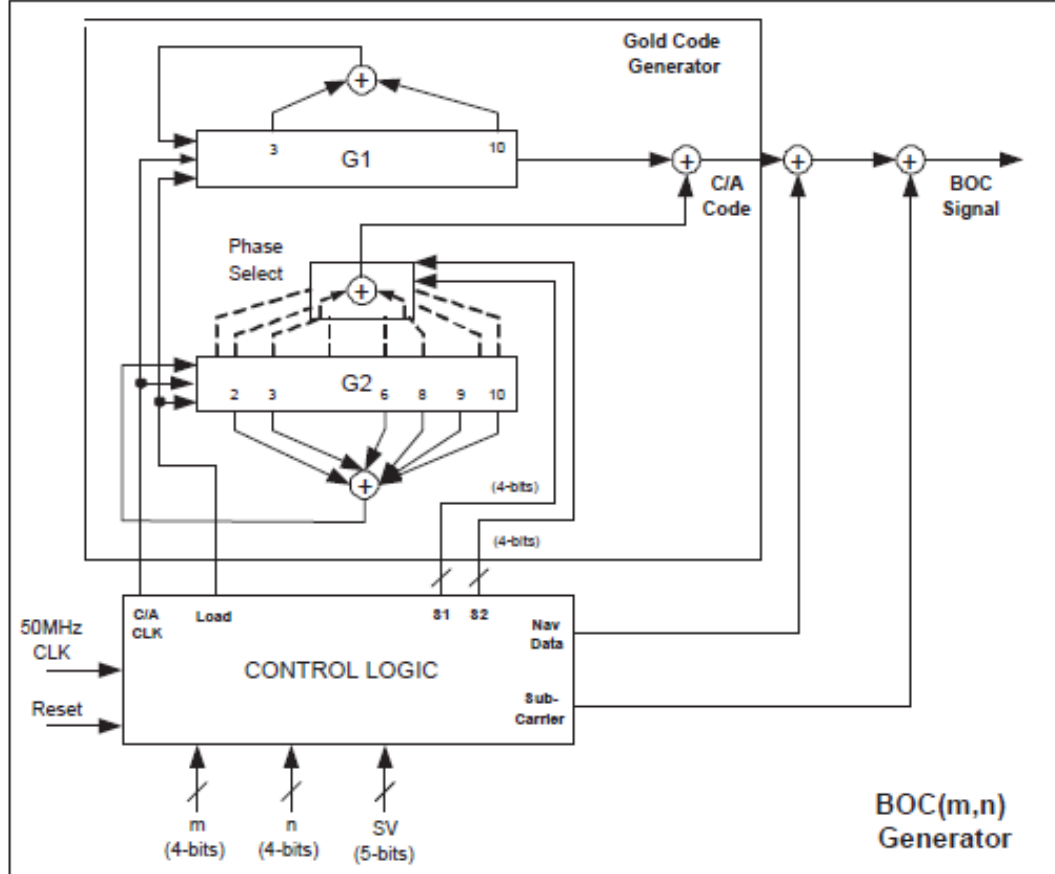


Embedded Systems

II) FPGA based base-band Signal Processing/Codec design for Navigation Systems

- A Binary Offset Carrier (BOC) code signal generator for GNSS
- Programmable
- FPGA based

BOC(m,n) FPGA Implementation



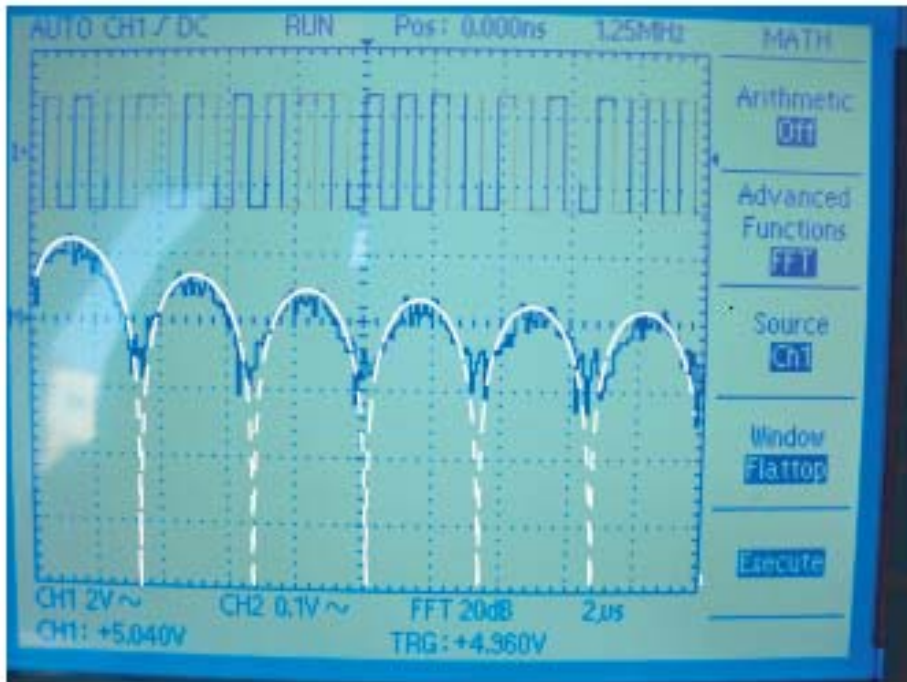
A: FPGA

B: (m,n) display

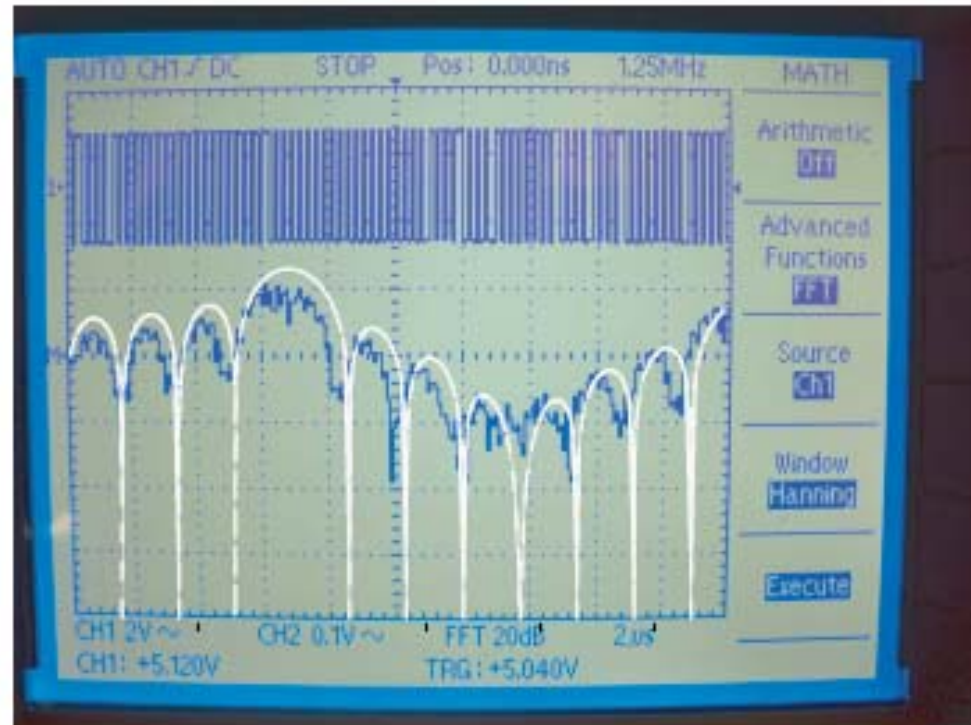
C: time domain PRN

D: PSD

BOC(1,1) and BOC(4,1)



BOC(1,1)

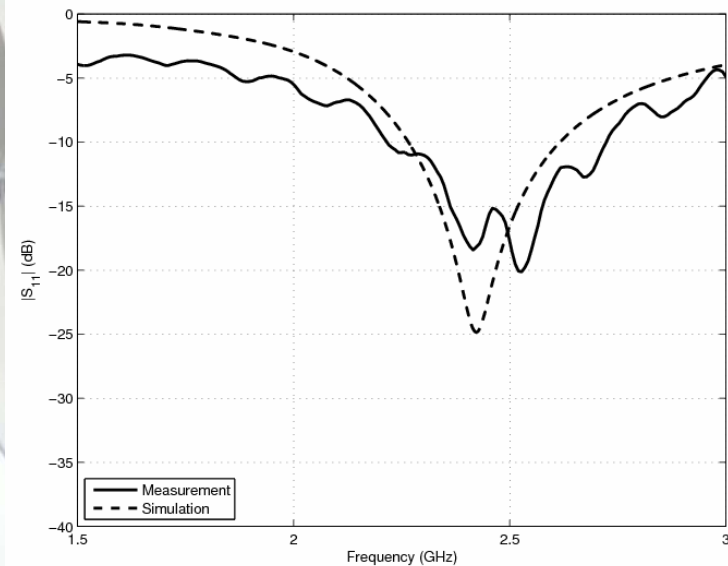
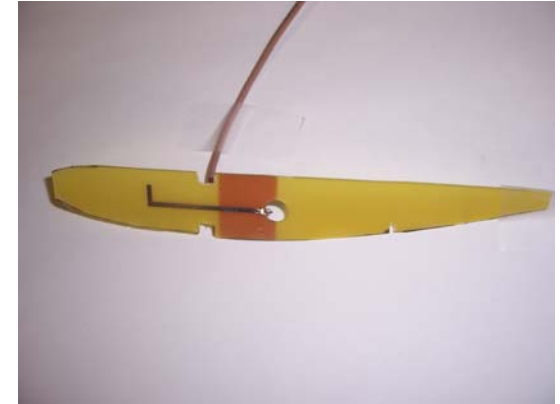


BOC(4,1)

[5] M. S. Sharawi and D. N. Aloï, "A Programmable FPGA Implementation of a multi-coded BOC(m,n) signal generator for Navigation Systems," IEEE MWSCS 2008.

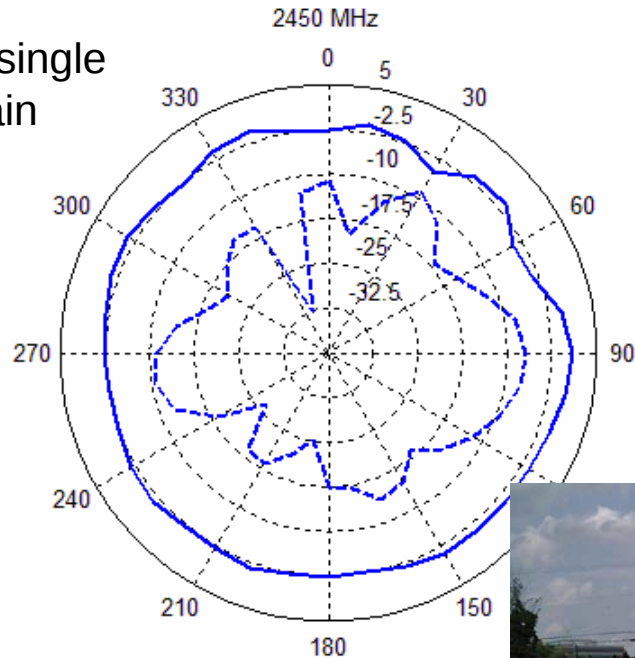
C. RF Electronics and Phased Arrays

- A project funded by MSGC (and NASA).
- Embedding antennas and phased arrays in structural components of UAVs.
- Results under review as we speak!
- RF + Embedded Systems.

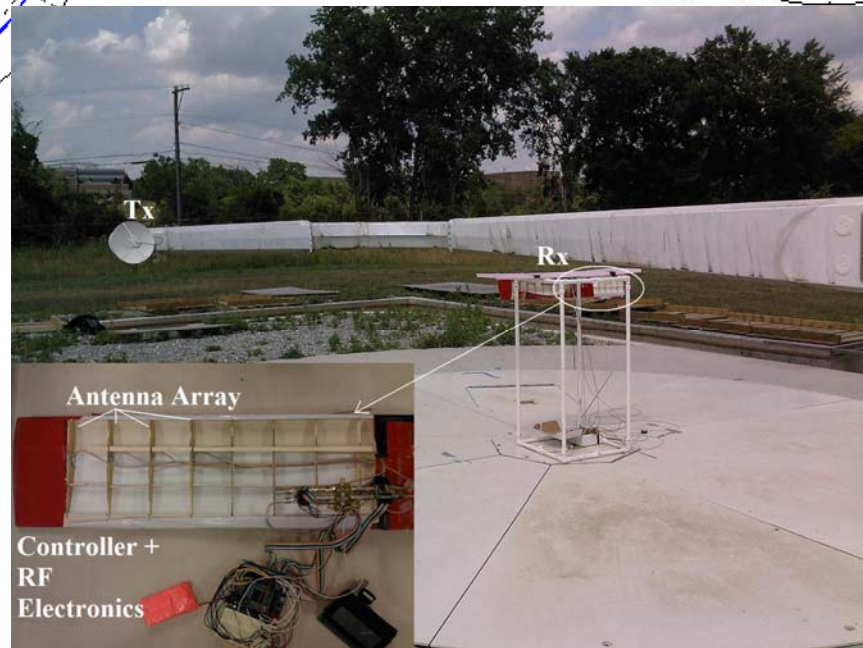
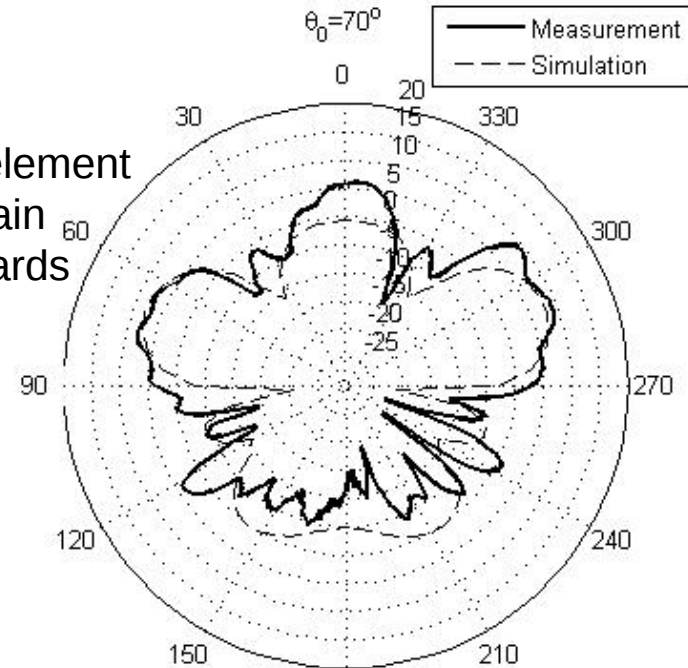


C. RF Electronics and Phased Arrays

Measured single element gain patterns



Measured 4-element linear array gain patterns (towards 70°)

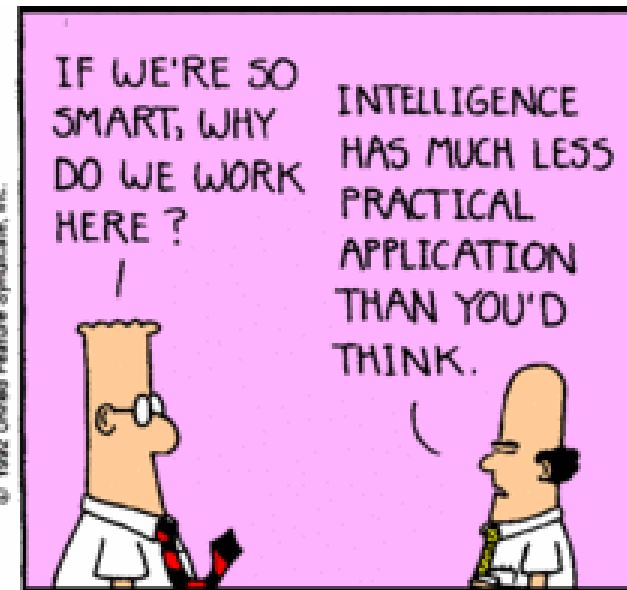
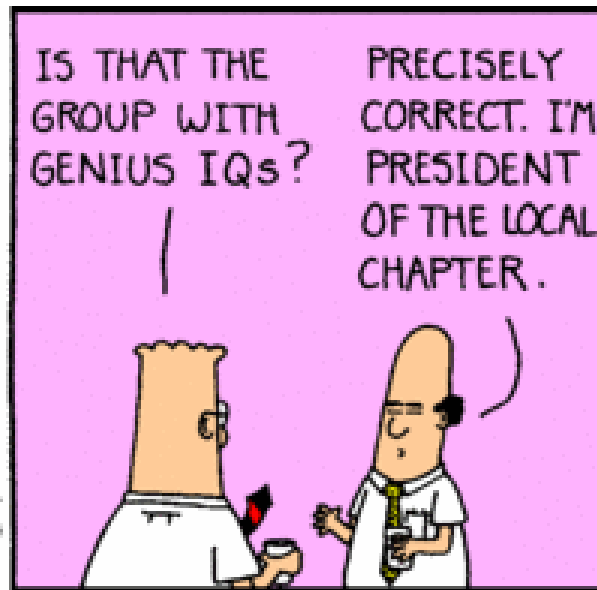


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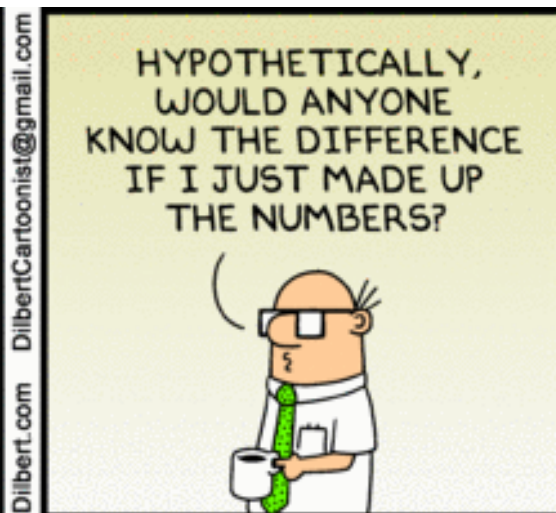
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Closing Remarks ...

- System level design necessitates multi/inter-disciplinary collaboration
- A new trend in Education is leaning towards MDE
- In our Arab world, this will be beneficial (?)
- A capstone project that is MD is highly recommended by major schools and universities



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THANK YOU!

