

# Welcome to

## **DESIGNCON<sup>®</sup> 2023**

**WHERE THE CHIP MEETS THE BOARD**

### **Conference**

January 31 – February 2, 2023

*Santa Clara Convention Center*

### **Expo**

February 1 – 2, 2023



# The Future of Power Integrity Through the Eyes of Experience

Istvan Novak, Samtec

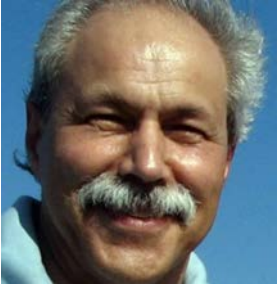


# SPEAKER

## Istvan Novak

*Principal Signal and Power Integrity Engineer, Company*

Istvan.novak@samtec.com, www.samtec.com www.electrical-integrity.com



Istvan Novak is a Principal Signal and Power Integrity Engineer at Samtec, working on advanced signal and power integrity designs. Prior to 2018 he was a Distinguished Engineer at SUN Microsystems, later Oracle. He worked on new technology development, advanced power distribution, and signal integrity design and validation methodologies for SUN's successful workgroup server families. He introduced the industry's first 25  $\mu\text{m}$  power-ground laminates for large rigid computer boards and worked with component vendors to create a series of low inductance and controlled-ESR bypass capacitors. He also served as SUN's representative on the Copper Cable and Connector Workgroup of InfiniBand, and was engaged in the methodologies, designs and characterization of power-distribution networks from silicon to DC-DC converters. He is a Life Fellow of the IEEE with twenty-nine patents to his name, author of two books on power integrity, teaches signal and power integrity courses, and maintains a popular SI/PI website. Istvan was named Engineer of the Year at DesignCon 2020.



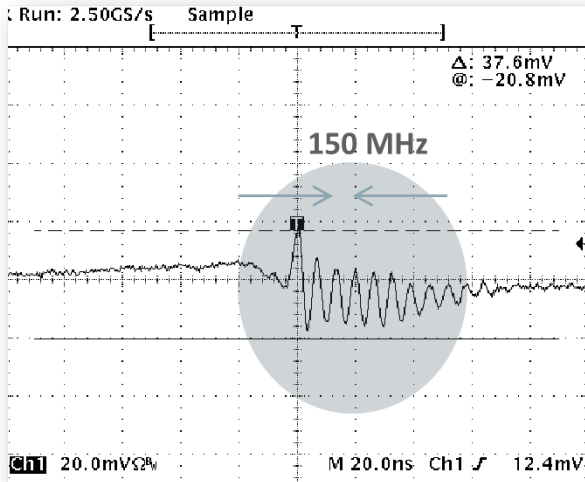
# OUTLINE

- What matters for power integrity
- Understanding the past
- Past predictions
  - What was correct
  - What failed
- Predictions



# What Matters for Power Integrity

- Power source
- Power distribution
- Power consumer

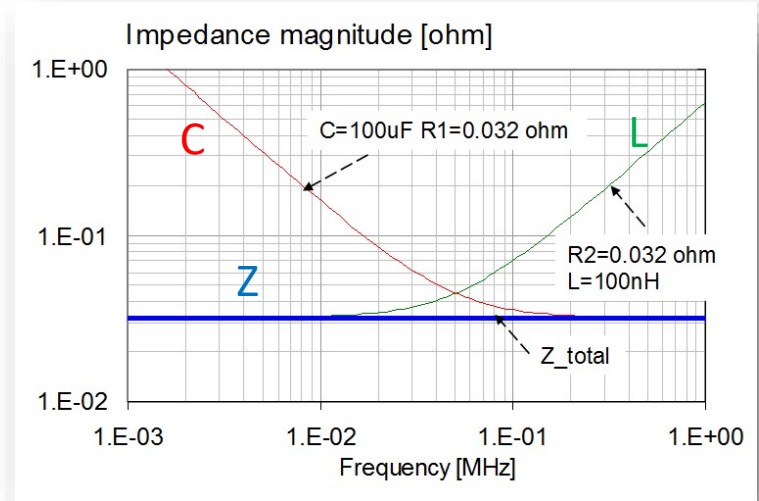


- \* 1) Providing clean power to electronics (PI)
  - Key: proper impedance profile and/or transient response
- \* 2) Provide solid return path for signals (optional), (SI)
  - Key: proper stackup, layout and connector pin-assignment
- \* 3) Keep outgoing (conducted/radiated) noise low (EMC)
- \* 3) Keep susceptibility low (EMI)
  - Key: resonance-free PDN structure
- \* 4) Support proper thermal design



# What to Watch for Power Integrity

- \* Power density and quality of source
  - Power density may impact power integrity
  - Loop stability and bandwidth of regulated sources
- \* Interconnect frequency response  
(inductance, capacitance, physical loop size)
- \* Power consumer's sensitivity to noise

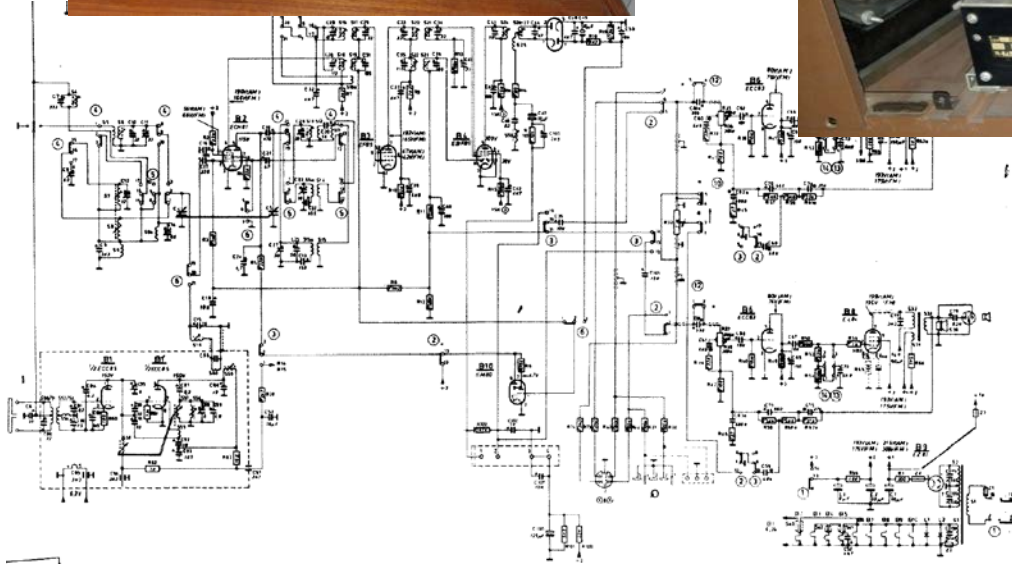


# Predicting the Future of Power Integrity

- First we need to understand the past that led to the present



# Philips Table-top Vacuum-tube Radio from 1963



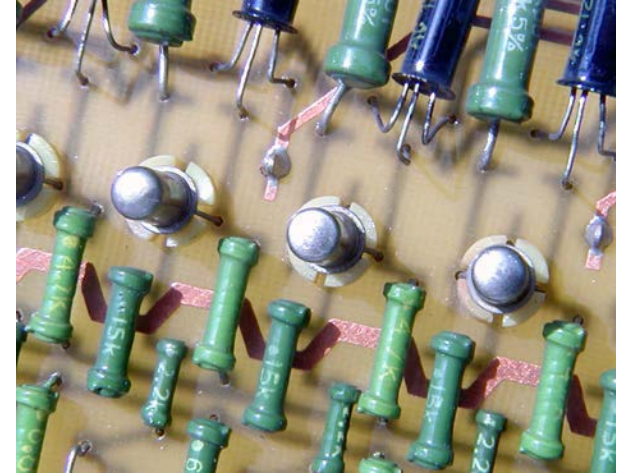
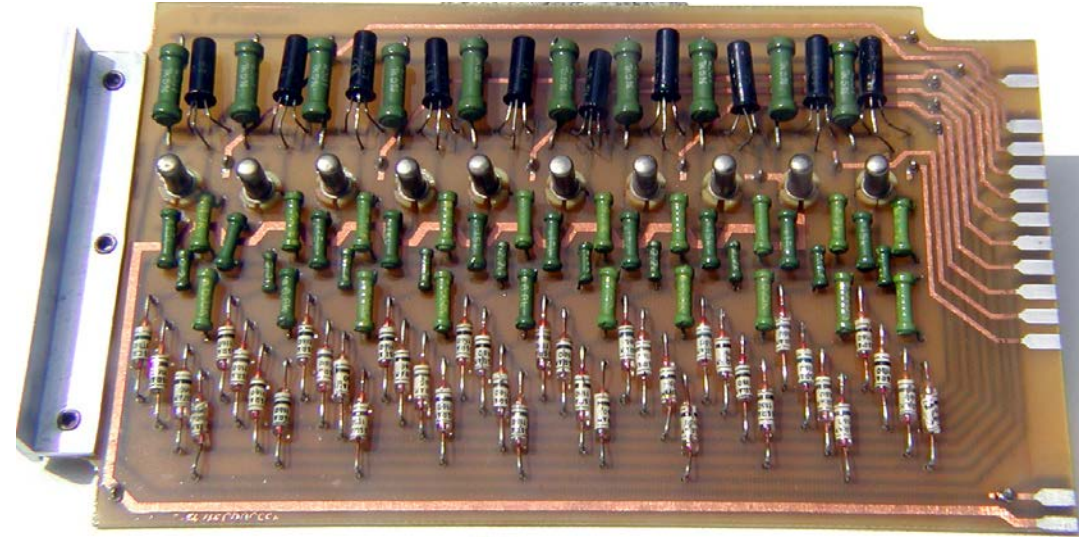
- ❖ At the beginning of times...
- ❖ There were wires
- ❖ 50-60Hz iron-core transformers
- ❖ Electrolytic capacitors
- ❖ uHs wire inductance



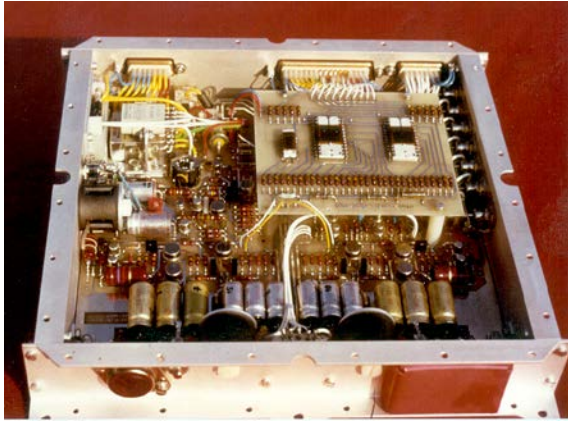


# Discrete Computer Board from the 1970s

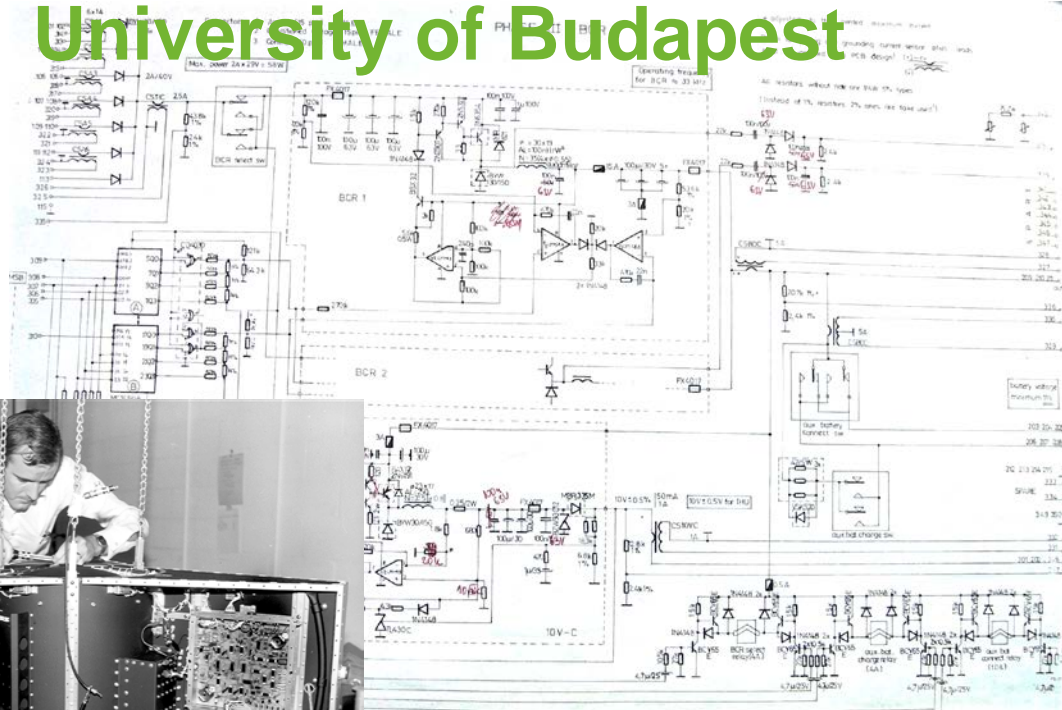
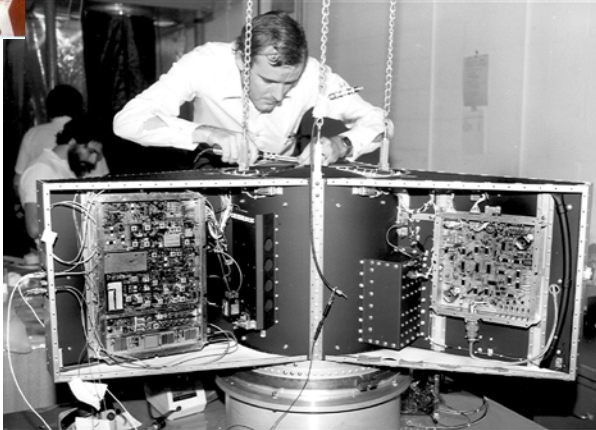
- ❖ Two-layer printed circuit board
- ❖ Traces to carry power and ground around, few hundred nH inductance
- ❖ No bypass capacitor



# Satellite Power Supply from 1982, Technical University of Budapest



- ❖ 58W max power
- ❖ Printed circuit board
- ❖ 33kHz, ferrite core inductors
- ❖ Electrolytic capacitors
- ❖ Few tantalum capacitors



Tribute to my former mentors, colleagues and friends:  
András Gschwindt, Richard Redl, András Bánfalvi,  
József Kertész and many others

# Server CPU Board from the 2000s

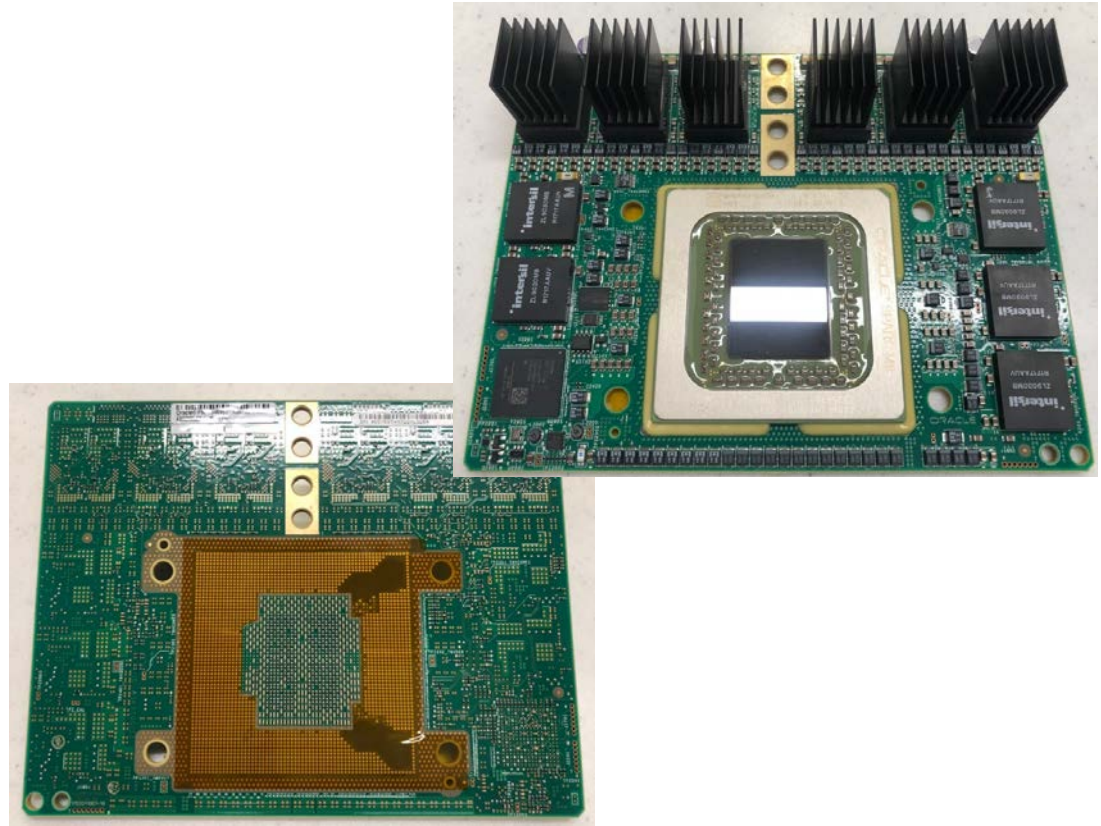
- ❖ SUN Microsystems V880/V890 CPU module
- ❖ 2 CPUs, 16 DIMM slots
- ❖ 1.8V/50A core rail per CPU
- ❖ 20" x 8.5" board size
- ❖ 20+ layers, thin power-ground laminates
- ❖ 10s of pH laminate inductance
- ❖ 1901 bypass capacitors





# Server CPU Board from the 2010s

- ❖ Oracle M8/T8 CPU module
- ❖ 1 CPU, 2 core domains
- ❖ Six-phase DC-DC converters for each core domain
- ❖ 6" x 5" board size
- ❖ 20+ layers, thin laminates, few pH laminate inductance
- ❖ 637 bypass capacitors

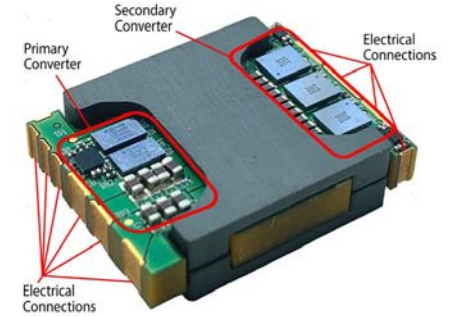
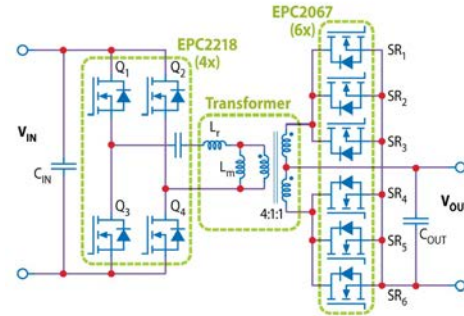
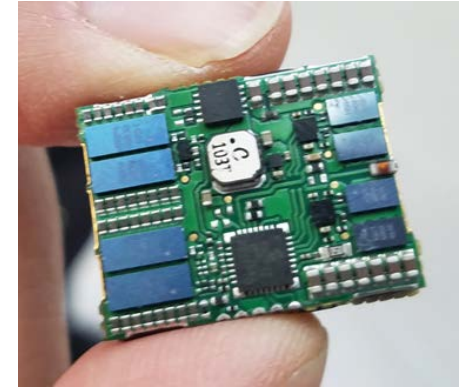
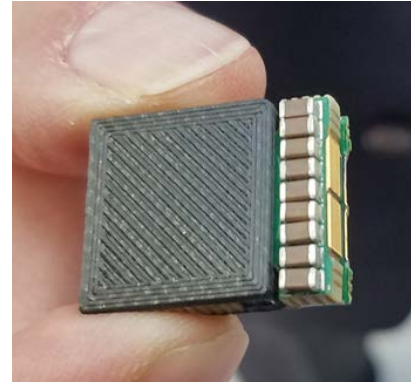


# 2023 PI Components, Technologies and Solutions

- ❖ DC-DC converter power density is up to  $4\text{kW}/\text{cm}^3$
- ❖ IVR
- ❖ Vertical Power Delivery
- ❖ Additive manufacturing



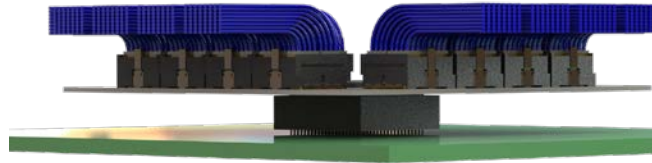
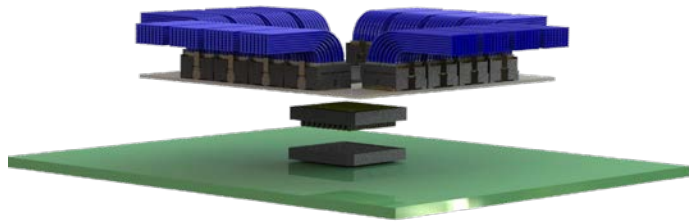
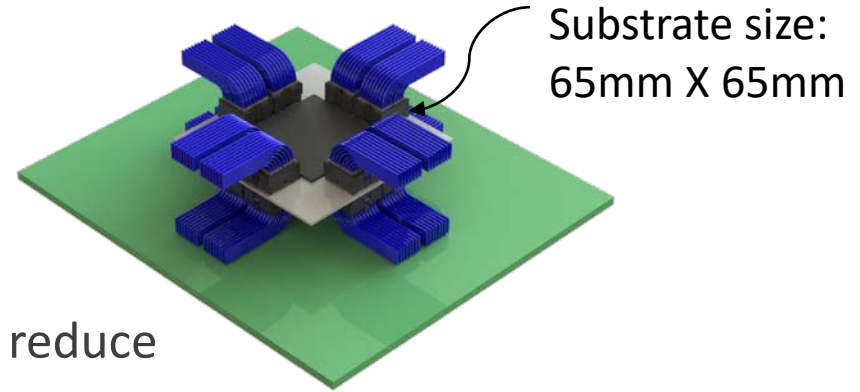
<https://www.vicorpower.com/industries-and-innovations/power-on-package>



<https://ebooks.aspencore-media.eu/pen/2022/december/mobile-responsive/#section=11>

# Near-Future Possibilities: the EPIC Concept

- ❖ Samtec Si-Fly™ on top and/or bottom of package for high speed
- ❖ EPIC on bottom to provide power
- ❖ Discrete capacitors embedded in EPIC to reduce inductance
- ❖ High speed and high power are totally separated

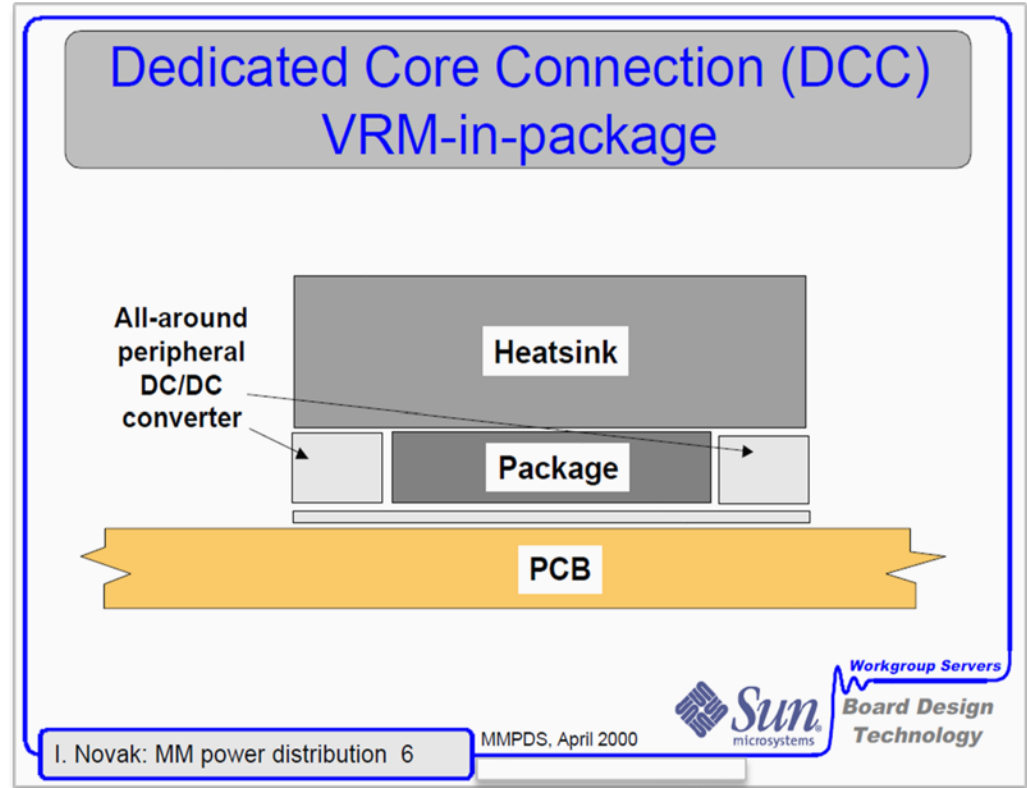


EPIC prototype



# Near- and Mid-Future Possibilities: IVR

- ❖ Only higher-voltage unregulated power rails to major consumers
- ❖ Pipe-dream from 25 years ago
- ❖ Gradually it is becoming now technically possible (but is it going to be feasible?)





# Predicting the Future of Power Integrity

- Who has the crystal ball?



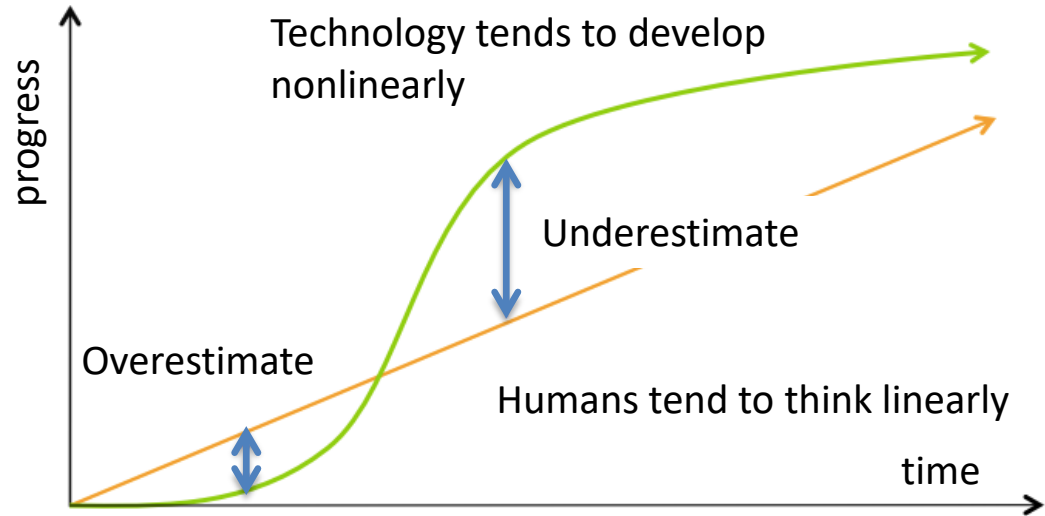


# Predictions: Amara's Law

“We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run.”

— Roy Amara

[https://en.wikipedia.org/wiki/Roy\\_Amara](https://en.wikipedia.org/wiki/Roy_Amara)



# Past Predictions

Nikola Tesla Quote from 1926:

When wireless is perfectly applied the whole earth will be converted into a huge brain, which in fact it is, all things being particles of a real and rhythmic whole. We shall be able to communicate with one another instantly, irrespective of distance. Not only this, but through television and telephony we shall see and hear one another as perfectly as though we were face to face, despite intervening distances of thousands of miles; and the instruments through which we shall be able to do this will be amazingly simple compared with our present telephone. A man will be able to carry one in his vest pocket.

<https://www.geekwire.com/2015/nikola-tesla-predicted-smartphones-in-1926-like-a-boss/>

Mark R. Sullivan, President of Pacific Telephone & Telegraph Co:



# Predictions

Debate with a college in the late 70s: which technology will prevail? LCD or LED?



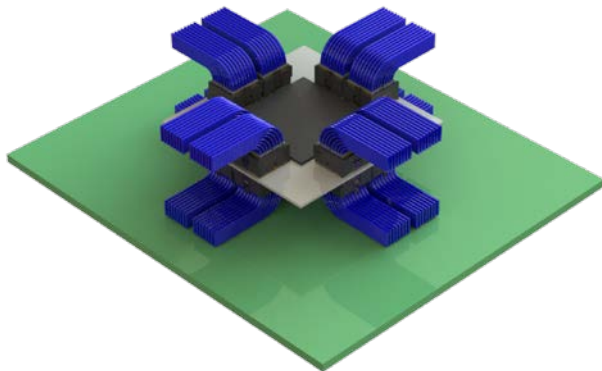
# Predictions

Keynote from DesignCon 1995

“In ten-to-twenty years, computers will look like hairy, steamy golf balls.”

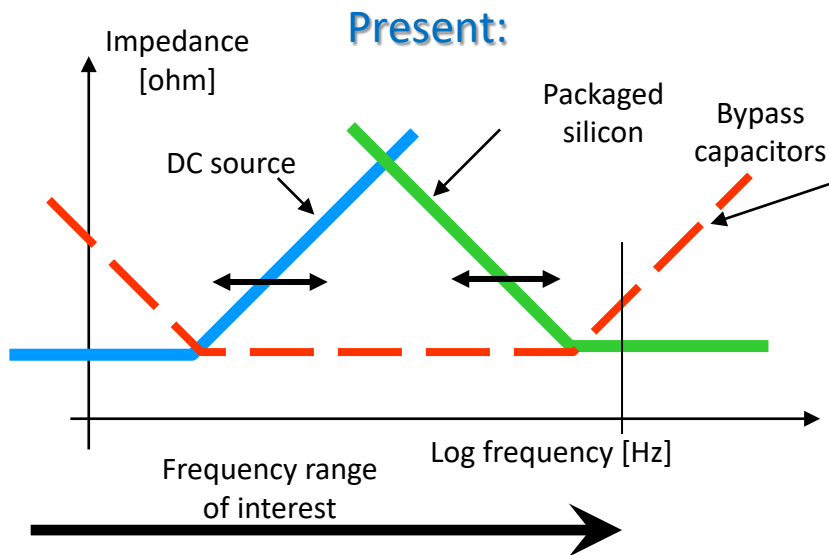
Three predictions... Only *one* of them was right. (I said in 2018)

But what about this five years later?

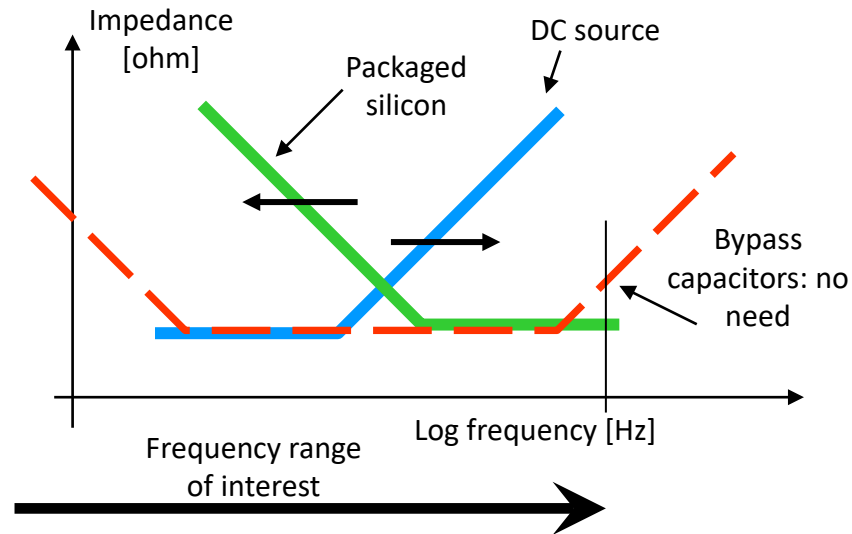


# Predictions

Istvan's keynote prediction from 2007: How many bypass capacitors do we need?



**Possible future:**



- ❖ Improve the bandwidth and functionality of the source and load
- ❖ Relieve the interconnect as much as much as possible



# Predictions

Looking out from 2023

- ❖ Improved bandwidth and functionality of the source and load
- ❖ PI interconnect will be relieved as much as much as possible
- ❖ Increased density and better immunity through smaller sizes
- ❖ SI-PI-EMI-Thermal co-design becomes the norm



# Thank you for attending !



## QUESTIONS?

