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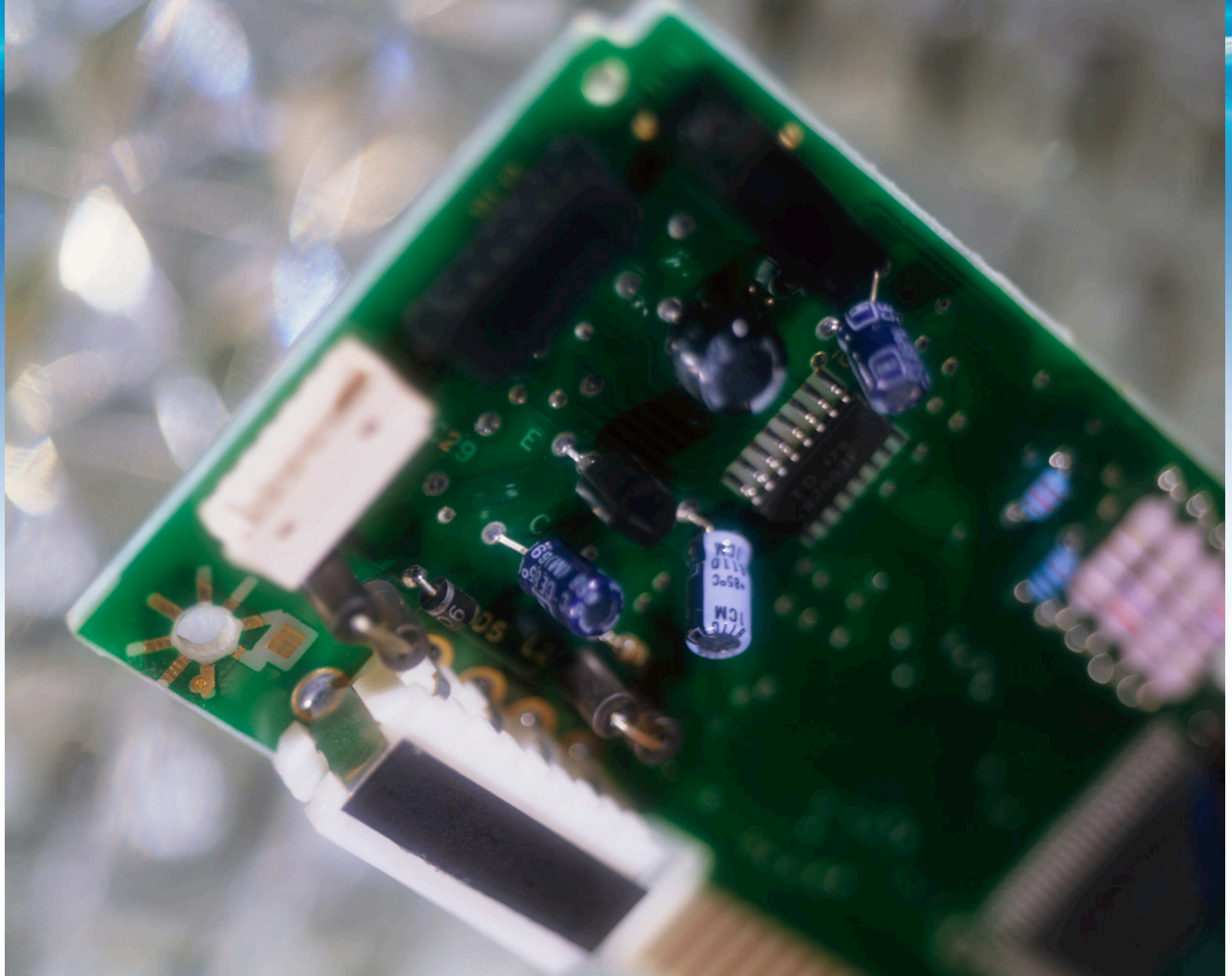
Custom Electronics Design
A Methodology for Success

Accelerator Reliability Workshop 2013

Tony Mowbray - ANSTO



Background Information – A Case Study

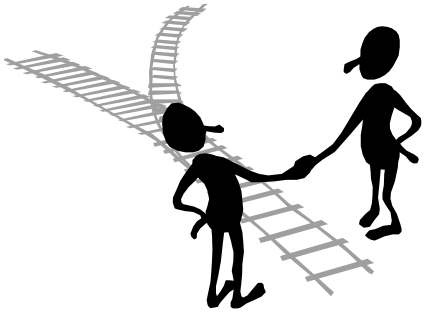
- ANTARES at ANSTO +40 years old, requires some ongoing tender loving care!
- 10MV, FN accelerator (FN1)
- Aging parts – time to bring these up to (modern) specifications
- Only 1 stripper gas – need more!

Background Information – Cont'd

- Opportunity to upgrade and improve internal systems – been ongoing for 20+ years
- Has had Pelletron Chains fitted to replace belts
- Using SF_6 as the tank gas instead of CO_2+N_2 at 500 kPa
- Some Terminal Upgrades
- Some of this (ongoing) journey forms the basis of this presentation

1st Steps – Provisional Solution

- Big Picture Creation
- Identify what it is you need to do
- Identify stakeholders
- Identify the end point you want to be at
- Start preliminary (block) design
- Get agreement that this is a good way to go



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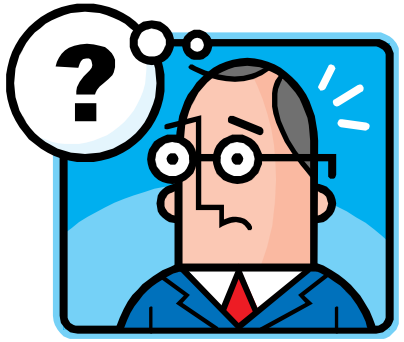
Decision Time – Buy vs. Build

- Provisional Solution Specified:
  - Buy – end of this story; or
  - Build, the story continues to evolve
- Where to in 10-20 years?
  - What you decide now drives where you go

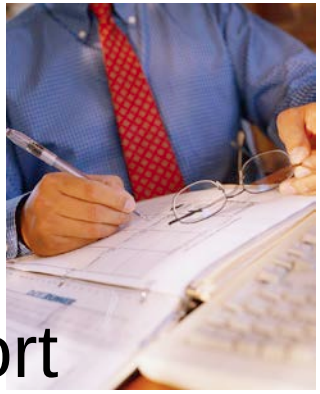


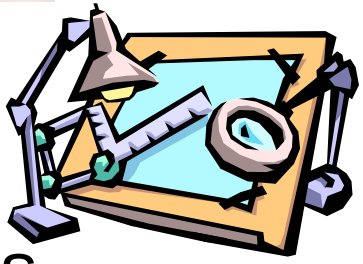
Do We Have To Build?

- Buy – gives fixed specs – it is what it is – some manufacturer support – 95% rule
- Build – gives greater flexibility – higher cost and risk (if not managed correctly) – in-house support only – some parts may be outsourced
- Incremental vs. Disruptive Technology
- The big vision – decide where you are going before you set out

Build Your Own…

- Scope the project and document it – update regularly, report often
- Understand the Problem
- Understand the Environment
- Get management buy-in and support
- Effective design – engineering/designer experience – maybe outsource?
- Realistic costings/timings – impact of delays





It's About Business

- This is a Business Process (Business Process Engineering)
- Follow basic business principles – Project Management, just like any other project
- Risk/Issue management - tools

Effective Risk Management

- Realistic Timing
- Realistic Costs
- Impact of Delays
- Develop Strategies
- Regular Status Updates
- Reporting

A Business Process…

Project Established

- Agreed Scope
- Risks vs. Rewards Identified

Commitment

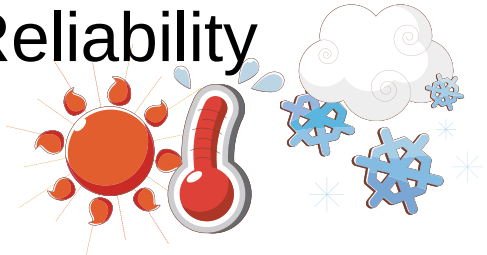
- Design & Proof of Concept
- Ongoing Funding & Support

Execution

- Build & Test Against Scope then Deploy
- Celebrate Wins and Plan Version 2.0

Probabilities and Possibilities

- Some Analogue aspects
- Some Digital aspects
- A/D and D/A and DSP
- Fibre Optics & Communications
- Hybrid Solution Most Likely
- Connections – Impedance Matching
- Enclosures
  - Ruggedness and Reliability
- Heating/Cooling



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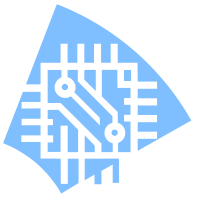
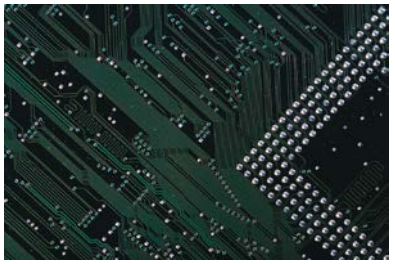
The Design Stage

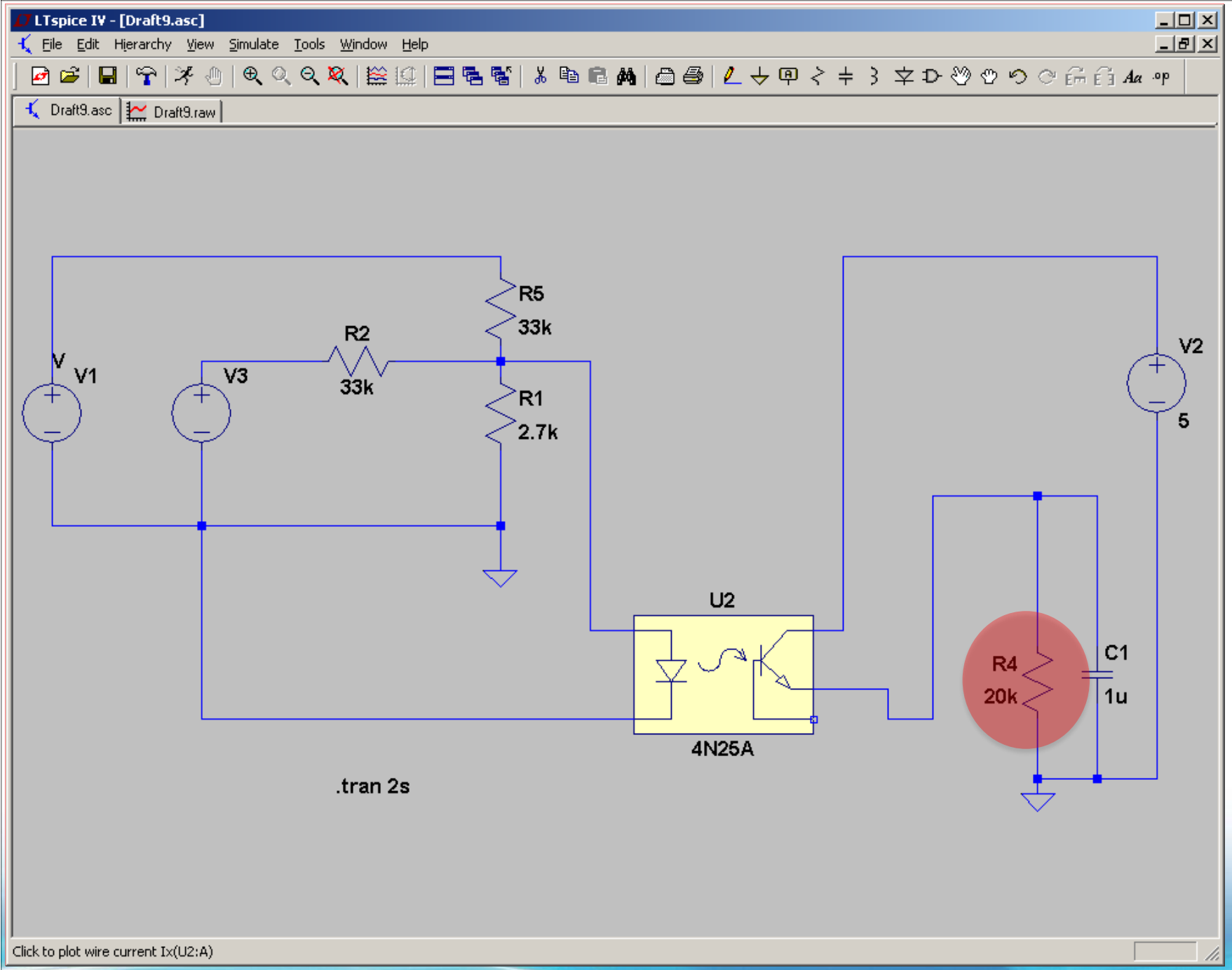
- Modular design – spares, ease of replacement
- Circuit Diagrams
  - Circuit design – analogue/digital/hybrid
- Technologies selected
- Communications – wired/wireless/optical
- Simulations – a real sanity check
- Prototypes
- HV Protection



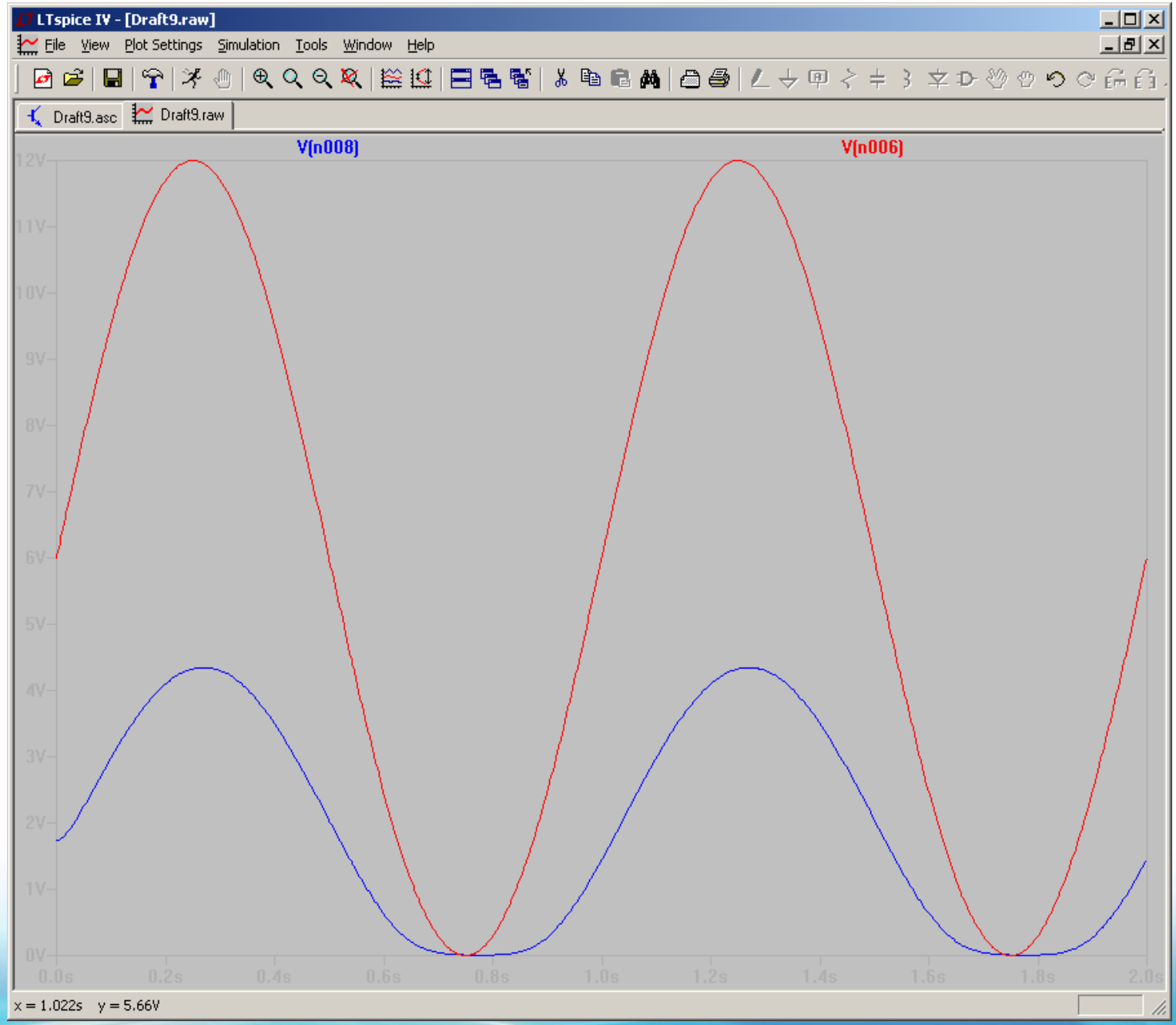


A Simulation

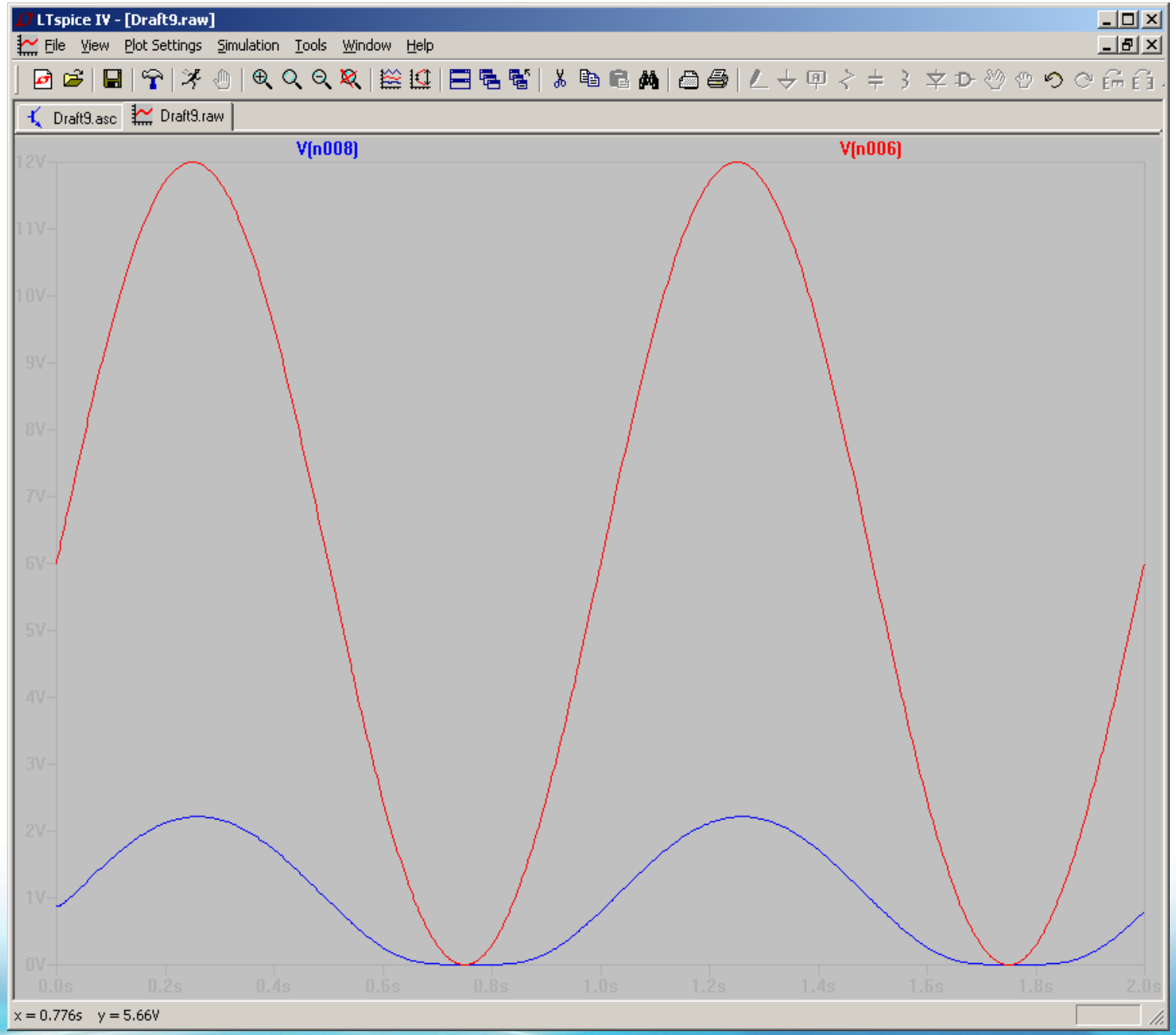
- Analogue Voltage to Voltage Isolator
- To allow an isolated analogue voltage input (Power Supply) to an A/D converter to monitor voltage level
- Using LTSpice from LINEAR TECHNOLOGY
- Fine Tune your Design before Build



- R4 can be 20k or 10k – which is right?



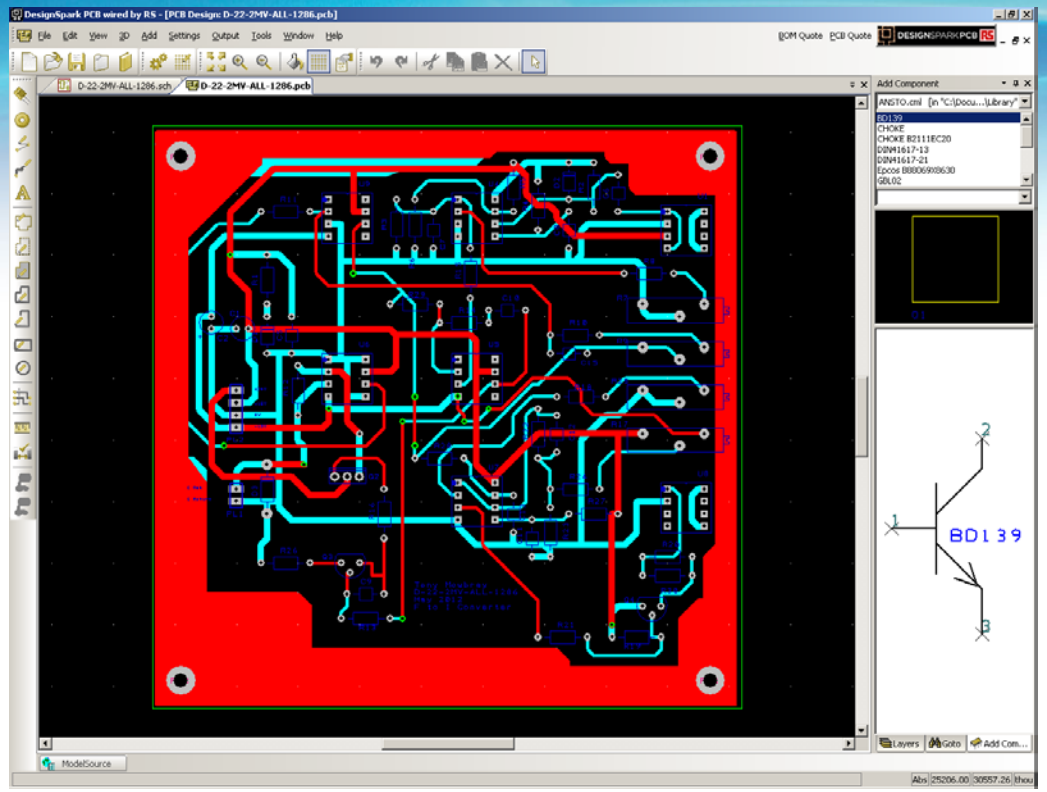
- R4 is 20k
- Red is I/P to Opto
- Blue is O/P

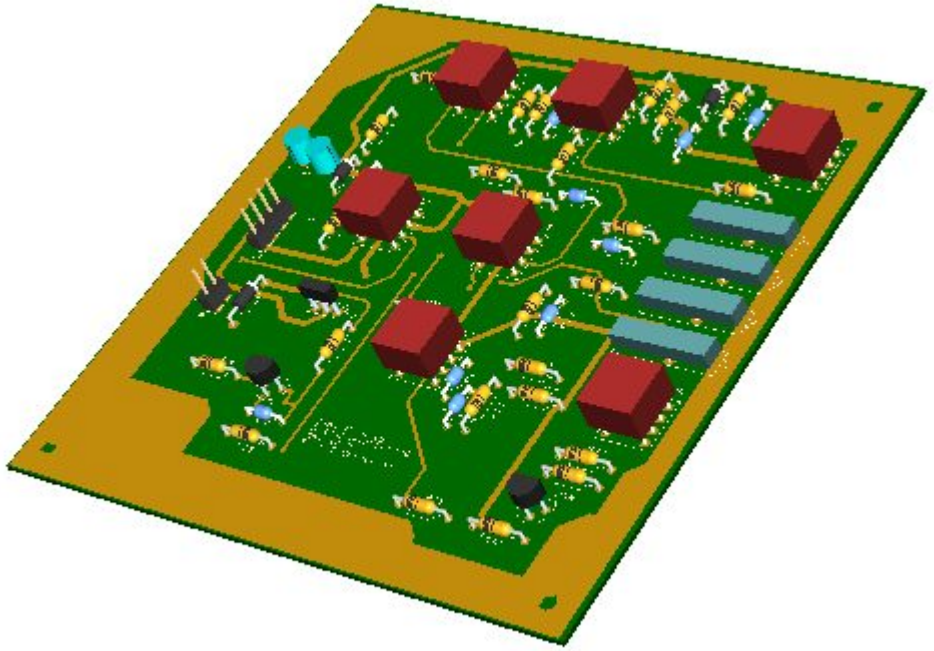


- R4 is 10k
- Red is I/P
- Blue is O/P of Opto
- Blue exhibits non-linearity and reduced O/P Range

PCB Design and Manufacture

- Simple PCB Design – Simple PCB Designer
- Complicated Design – Expensive PCB Designer
- I used DesignSpark from RS Components (up to 8 layers capable)
- 3D Rendering of your design
- Insource/Outsource options





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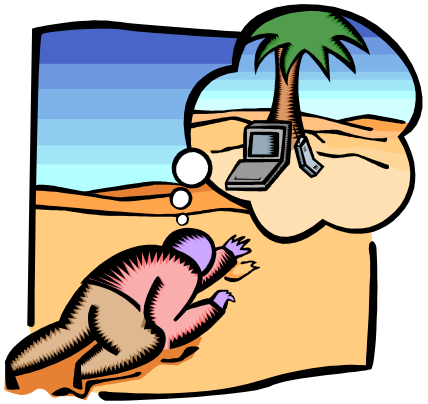
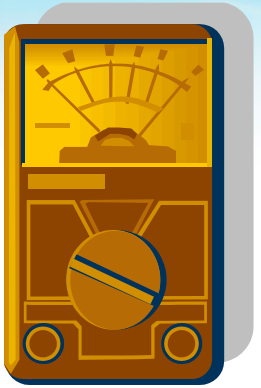
Our Design Considerations

- Our Opportunity – 2 weeks annually
- What happens when your protection elements fail?
- Fail Safe and Crawl/Limp home mode
- Auto reset



Testing the Waters…



- How to test
- Standardised testing methodologies
- Recording results – against specifications
- Calibrations
- Use Certifications that are traceable

Technical Infrastructure Alliance

NATA STANDARDS Australia JAS-ANZ Australian Government National Measurement Institute

A Member of Australia's Standards and Conformance Infrastructure

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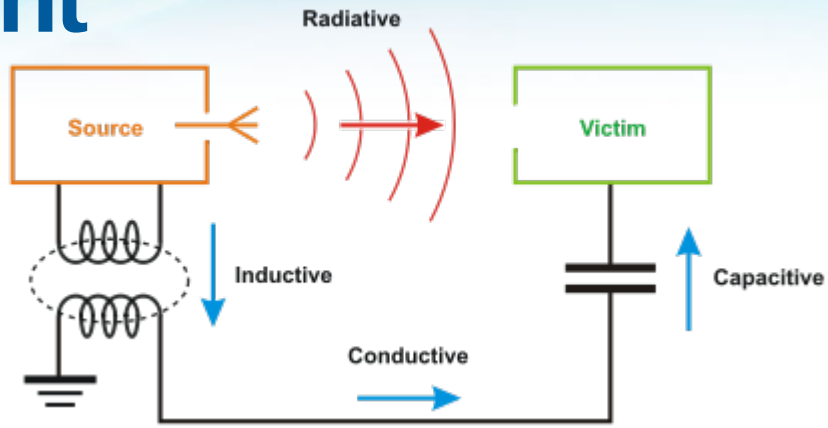
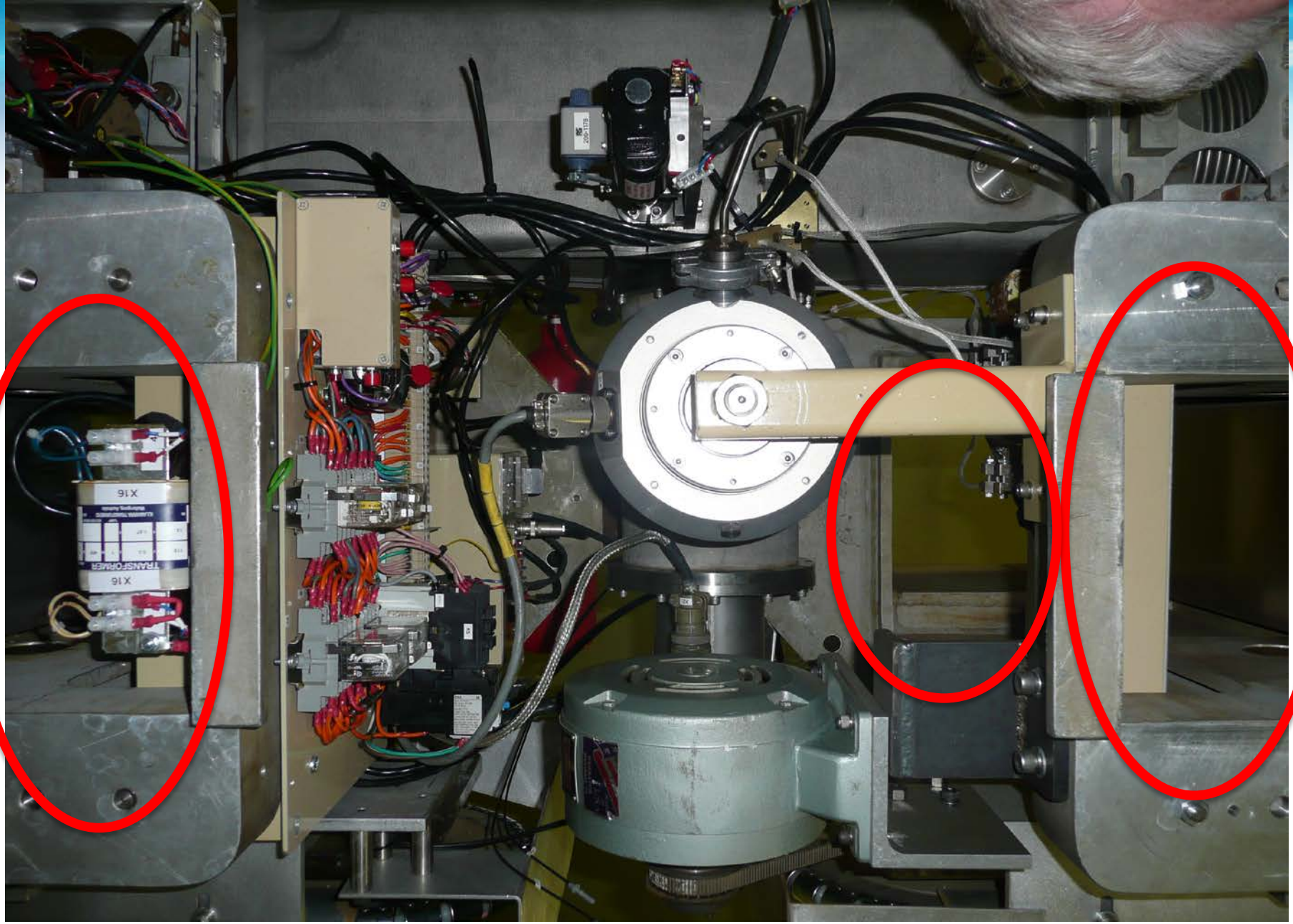
Commitment



- Assembly restrictions
  - Available space
- Co-existence and compatibility (EMI/EMC)
- Component/module sourcing – realistic lead times
- Interconnections
- Knowns vs. unknowns
- Sanity checks – peer review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Support Tools

- Manufacturer documentation
- Manufacturer sample circuits/components/free samples
- Manufacturer tech notes and specifications
- Reference materials
- Design software – CAD, Spice, PCB design – often free
- Mechanical support and availability

Support Tools – Cont'd

- Generated documentation
  - Reality/time/should do
- In-house:
  - Knowledge;
  - Experience;
  - Expertise;
    - Think, Play Do!

Practical Application we used

- ANTARES 10MV Ion Accelerator at ANSTO
- Terminal Power Supplies
- Relay Logic activated through Fibre Optics
  - and µController (Ver 3)
- Feedback through Fibre Optics
- PIC µController inside terminal
- Plan to control a Current operated Thermo/Mechanical Leak next opening

Practical Application – Cont'd

- 2 openings out, we will convert the other 2 leaks to current controlled operation
- Add other telemetry items
- Add other controlled items
- Continue using Fibre Optics
- Incremental Technology approach – 3 years to date
- Survived terminal sparks around 8MV

Version 2.0 and on

- What could be done better…
- Experiences gained
- Talent/knowledge gaps
- Continued management support

- Dare to imagine – gives you confidence to think bigger but know when to put a lid on it – always perform a “sanity check”

- Your (business) process works

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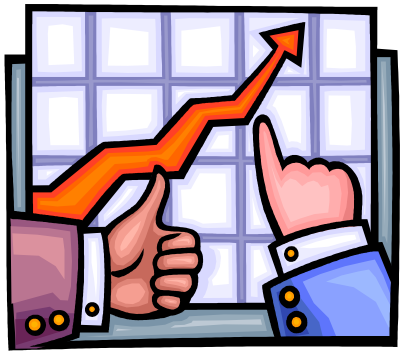
Summary

- Plan to succeed – Don’t be afraid to try something – you will always learn something, even if not to do it again – this is valuable research and should be documented by standard research methodologies

- Stick to your plan – if things change, modify your plan and timeframes accordingly – this process takes time to perfect and maybe several iterations

Summary – cont'd

- Take the time to learn your technologies and the tools to enable them – scour the internet for resources, much of it is free and short courses can also be found, as well as technical communities (ARW, SNEAP)
- Reliability IS part of the design process from the start, and will reward well if done right
- You can do it, and will get a great sense of satisfaction when you do…



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Some Useful References

- The Art of Electronics – Horowicz and Hill - 3rd Edition imminent – ISBN 978-0-521-37095-0
- Designing Electronic Systems for EMC – William G Duff – ISBN 978-1-891121-42-5
- Analog Circuit Design 1st Ed – A Tutorial Guide to Applications and Solutions – Bob Dobkin and Jim Williams – ISBN 978-0-123-85185-7
- Analog Circuit Design, Volume 2 – Immersion in the Black Art of Analog Design – Bob Dobkin and Jim Williams – ISBN 978-0-123-97888-2 – Just released!
- Trilogy of Magnetics – Design Guide of EMI Filter Design, SMPS and RF Circuits – Würth Elektronik – 4th Ed – ISBN 978-3-89929-157-5
- Trilogy of Connectors – Basic Principles and Connector Design Explanations – Würth Elektronik – 1st Ed – ISBN 978-3-89929-201-5
- Think, Play, Do: Technology, Innovation and Organisation – Mark Dodgson, David Gann, Ammon Salter – 1st Ed – ISBN 978-0-19926-808-5

Some Useful Websites

- www.analog.com – Analogue Devices – Spice, Models, Reference Designs
- www.ti.com – Texas Instruments – FilterPro, Spice, Models, Reference Designs
- www.linear.com – Linear Technology – LTSpice, Design Simulation, Reference Designs, Models
- www.we-online.com – Würth Elektronik
- www.autodesk.com – AutoCAD
- www.designspark.com – DesignSpark PCB, Noise Calc, other free tools