

Hands-on GaN Doherty amplifier design

Martijn F. Brethouwer
2022-06-01



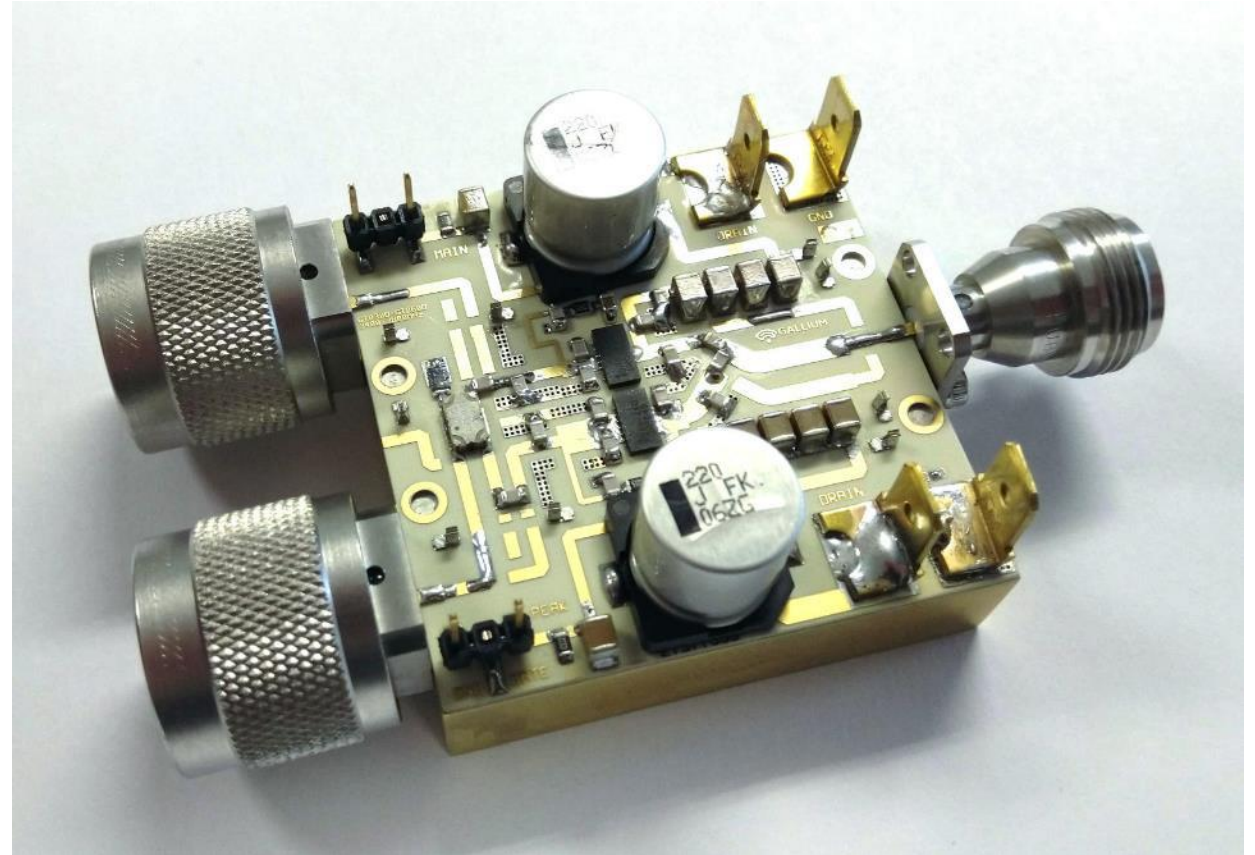
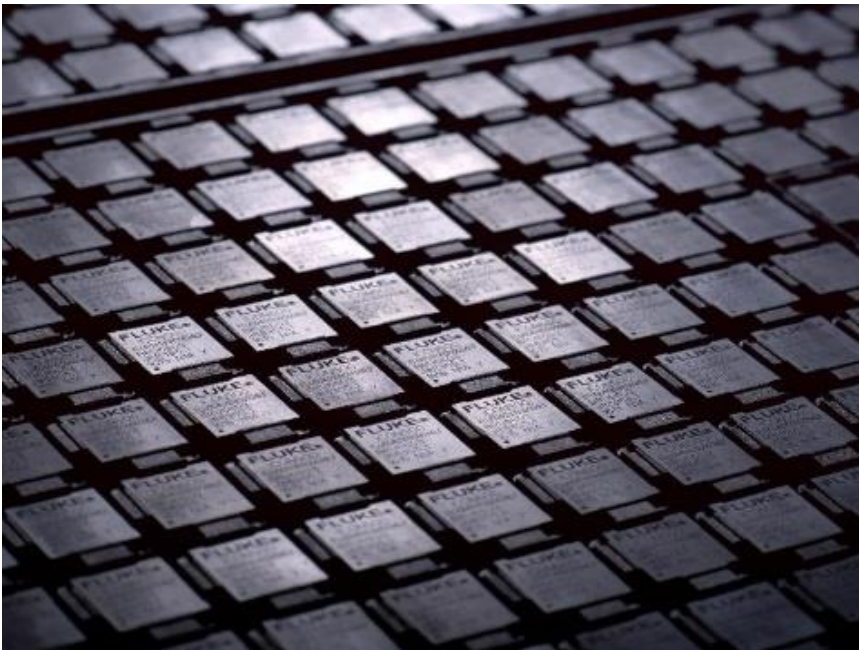
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Introduction

Bruco IC



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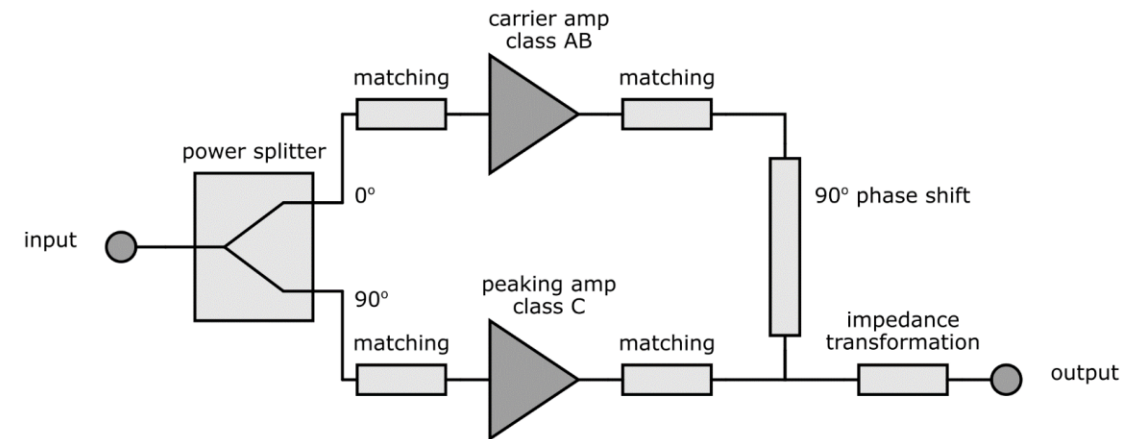
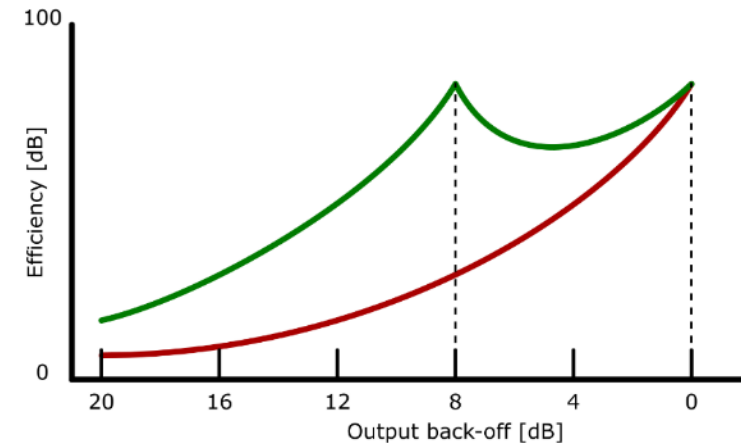


Introduction

Doherty amplifiers



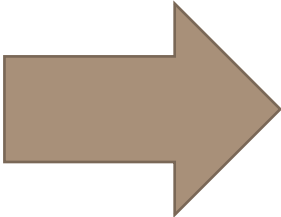
- Base-station applications
 - 1G -> 6G communication standards
 - High peak-to-average ratio signals
 - Good efficiency
- Doherty topology
 - Big improvement in efficiency
 - Many parts working together



Specifications

Doherty amplifiers

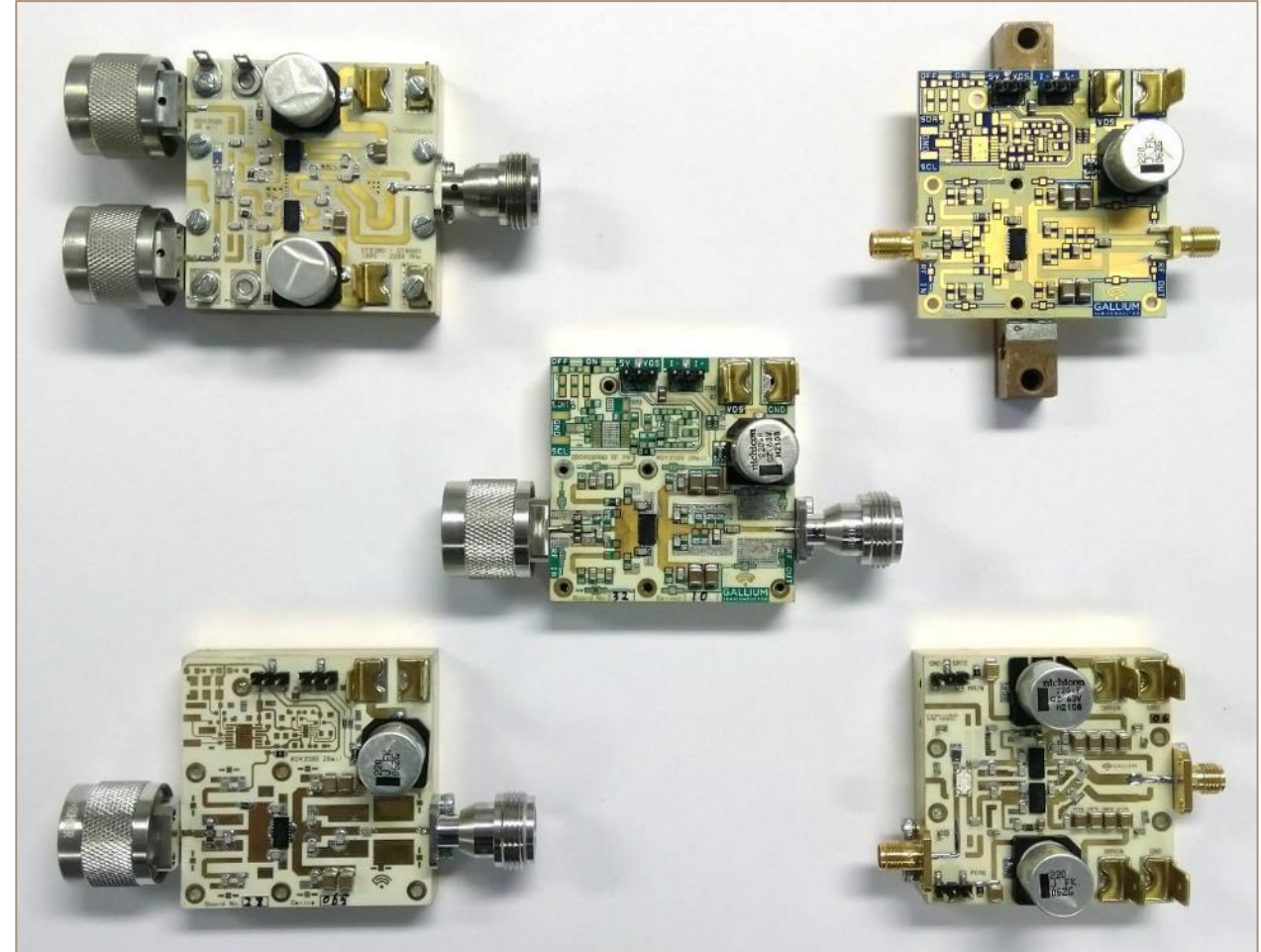


- System
 - Peak and average power
 - Frequency range
 - Efficiency
 - Gain
 - Area constraints
 - Component selection
 - Deliverables
 - Hardware
 - Measurements / Report
- 
- Mechanical
 - Construction
 - Soldering
 - Connectors
 - Electrical
 - Transistors selection
 - Wideband design or not
 - DC feed & baseband impedance
 - Bias control network or not
 - COTS component selection

General design rules

All designs

- Manufacturing
 - Number of pieces
 - Assembly
 - Soldering
 - PCB design rules
- Testing
- Reuse
 - To save time
 - To reduce errors

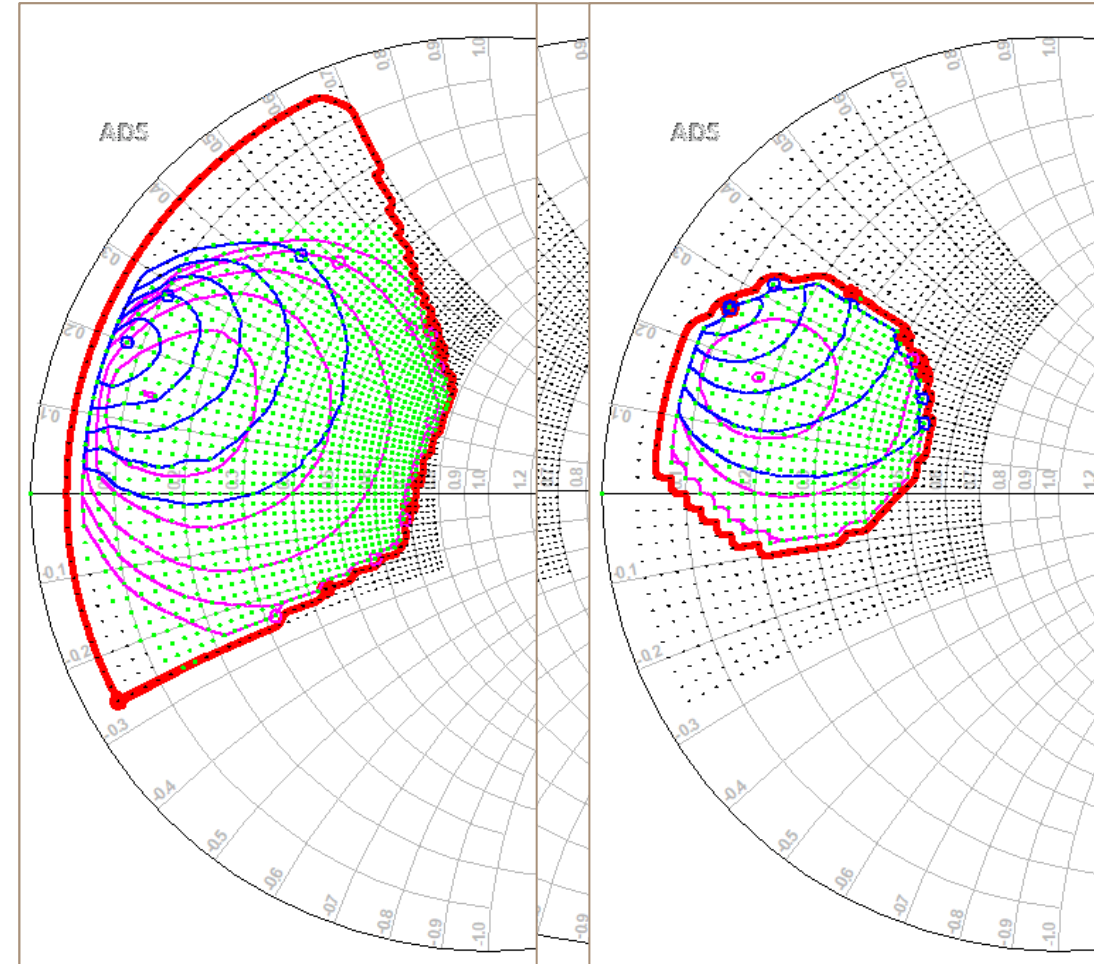
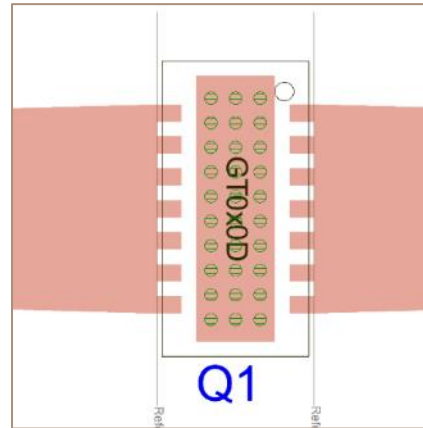
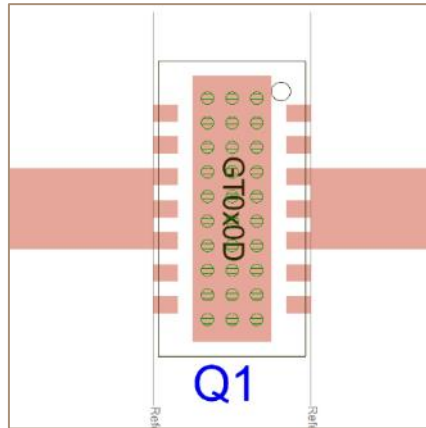


Transistor selection

Load-pull data



- GaN devices from Gallium semiconductor
- Load pull data
 - Frequency points
 - Fixtures & reference planes
 - Smith chart coverage for main transistor



Transistor selection

Load-pull system

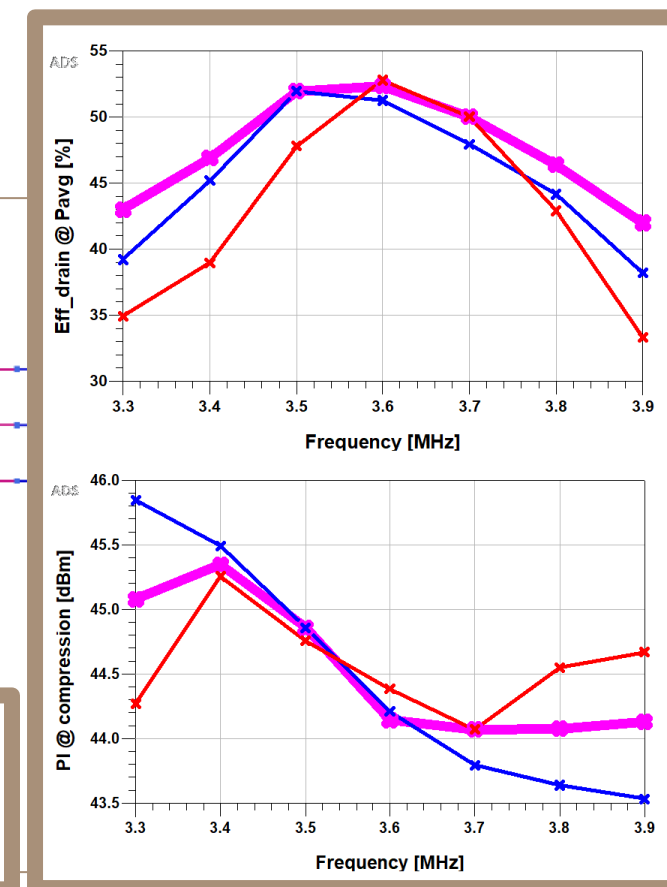
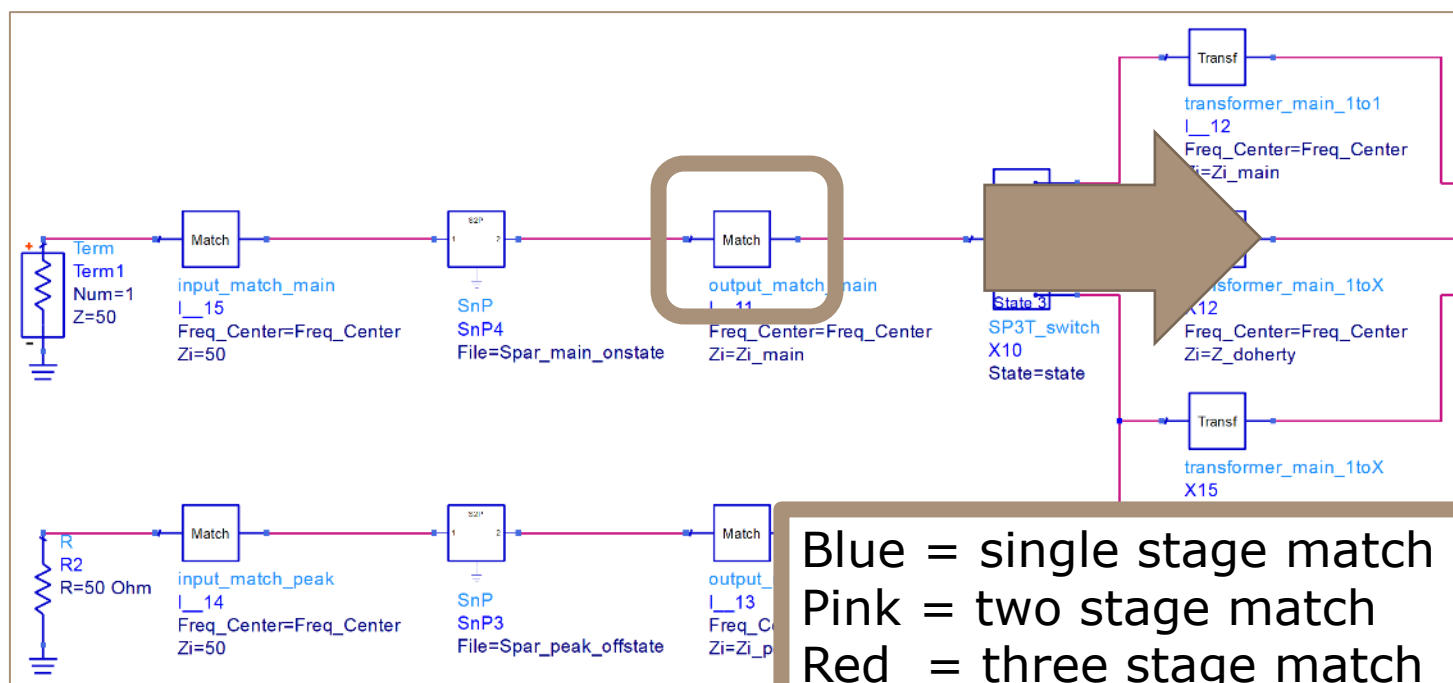


Simulation

High level



- Start with very basic design to get the design working (most hurdles are here)
- Intermediate impedances
- Check options for making wideband, what is beneficial?

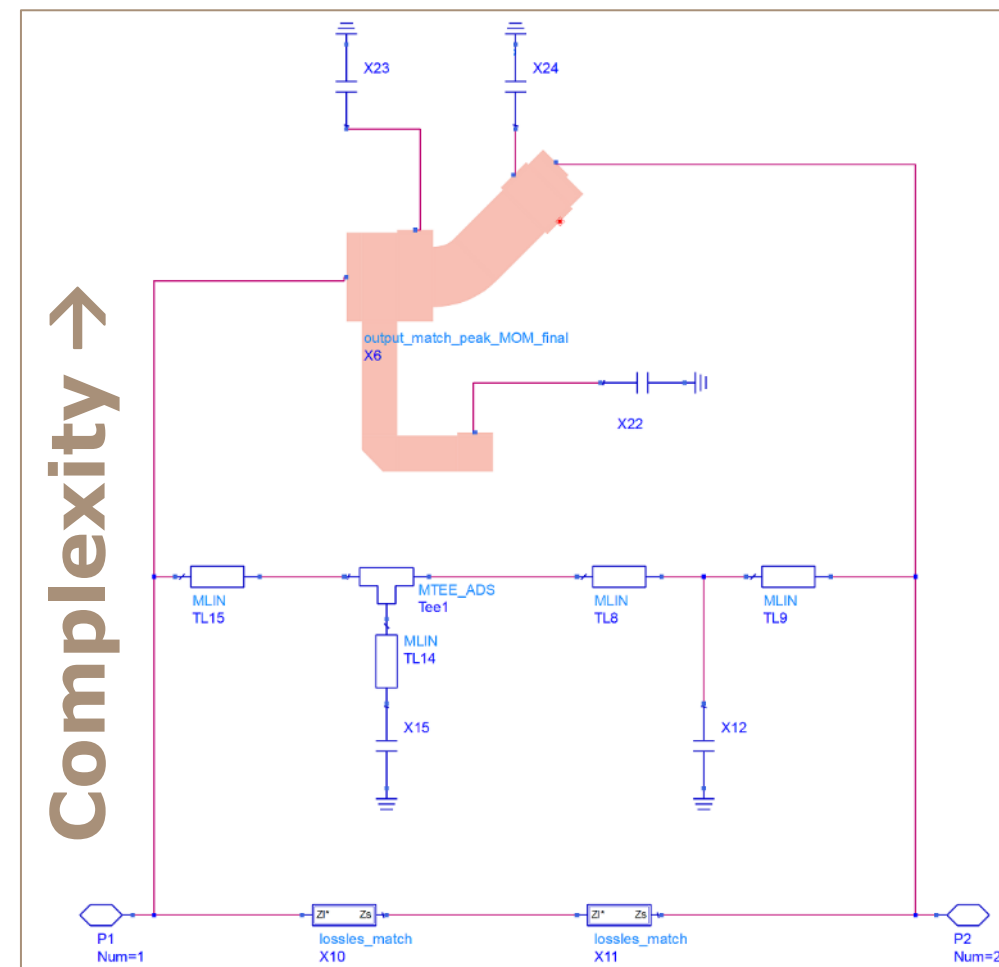


Simulation

Layout



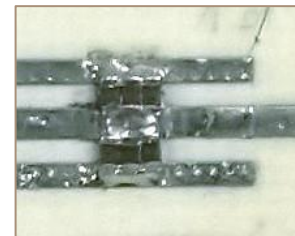
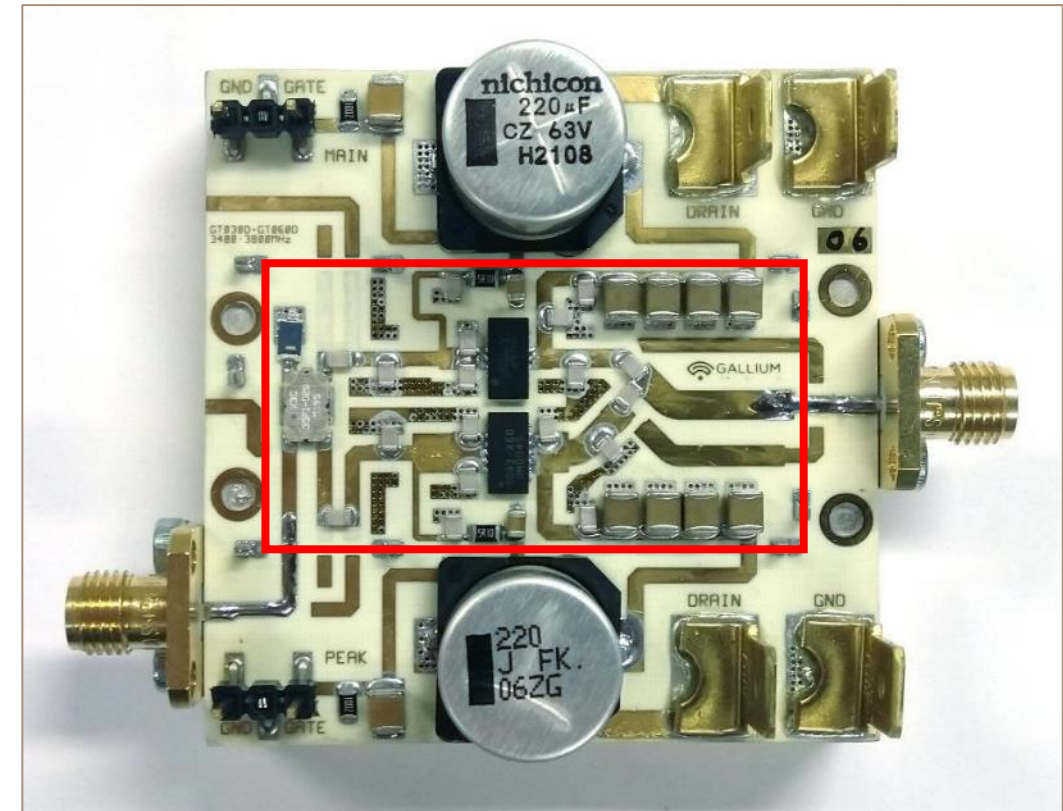
- Step-by-step increase complexity
 - Keysight / AWR webinars
 - Include DC bias
- Pitfall: Design for stability and testing early-on
 - Conditionally stable, also out-of-band
 - Test points / connectors / traces
- Pitfall: Use design for manufacturing early-on
 - Make tuning possible
 - Distance between components
 - Reproducibility



Mechanical Design



- Reserved area
 - Peripheral circuitry
 - Connectors
- Design for manufacturing
 - Distance between components
 - Component shift
 - Component footprints
 - Thermal strategy

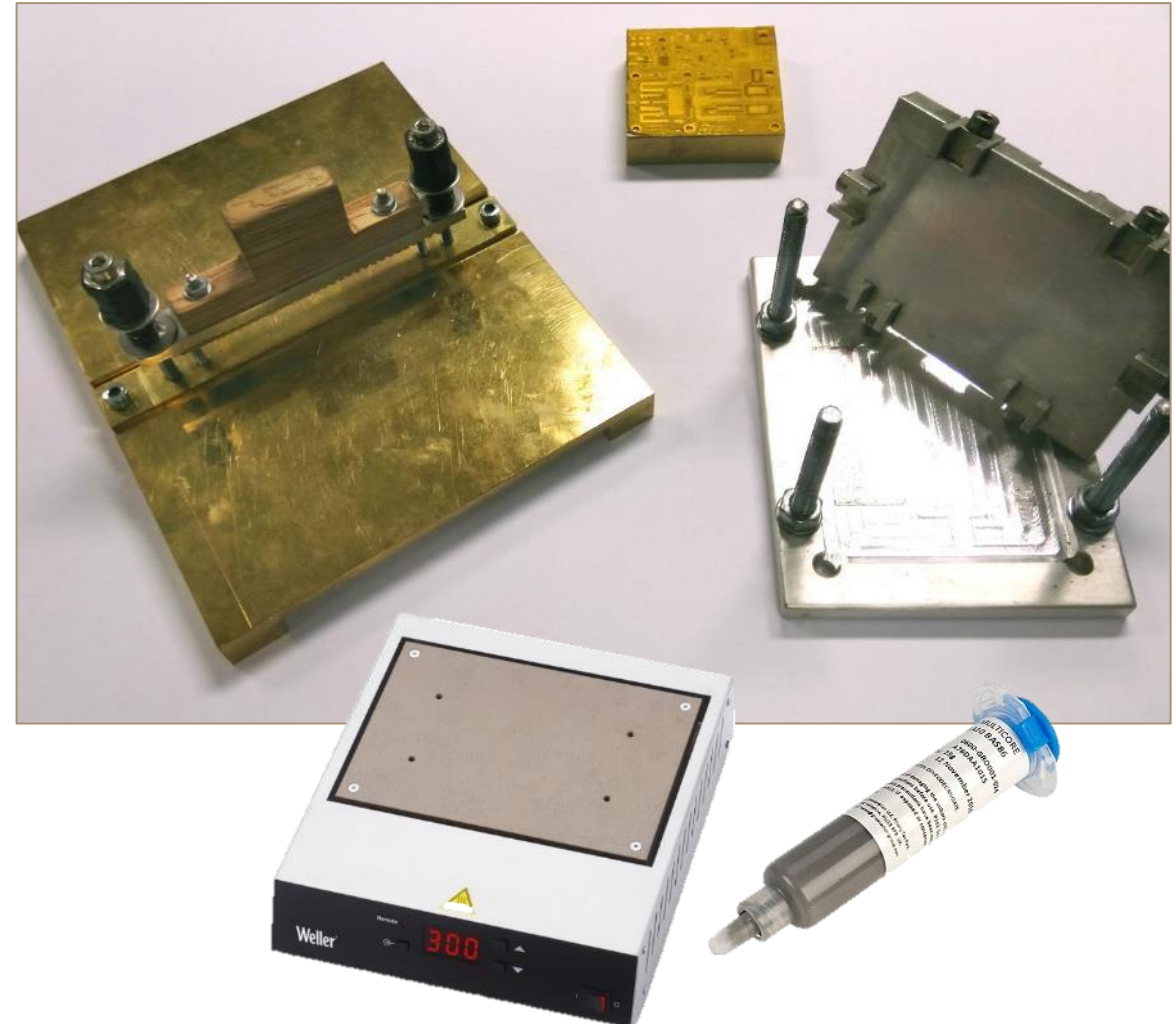


Mechanical

Construction



- **Work smart, not hard**
- If re-used a lot, design is much easier
 - Base plate dimensions (50 x 50 mm)
 - Molds and clamps
 - Templates for connectors
- All in-house incl. milling
- (reflow) soldering
- Reliable and consistent but flexible



Measurements

Testing & tuning

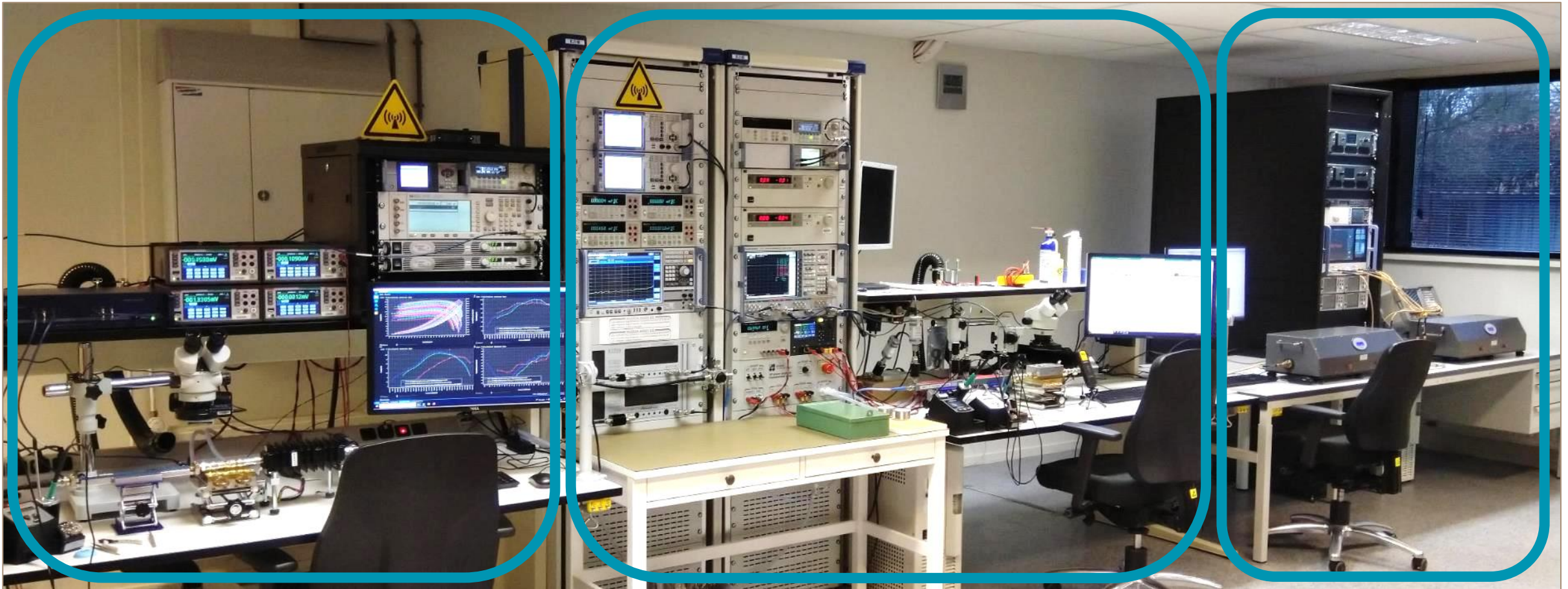


- Structured approach
 - Step-by-step to prevent finding a local optimum
 - Document results to enable comparisons
- Pitfalls:
 - Soldering without disabling PSU's
 - Damaged / degraded parts (capacitors)
 - Reproducibility



Measurements

Measurement setup

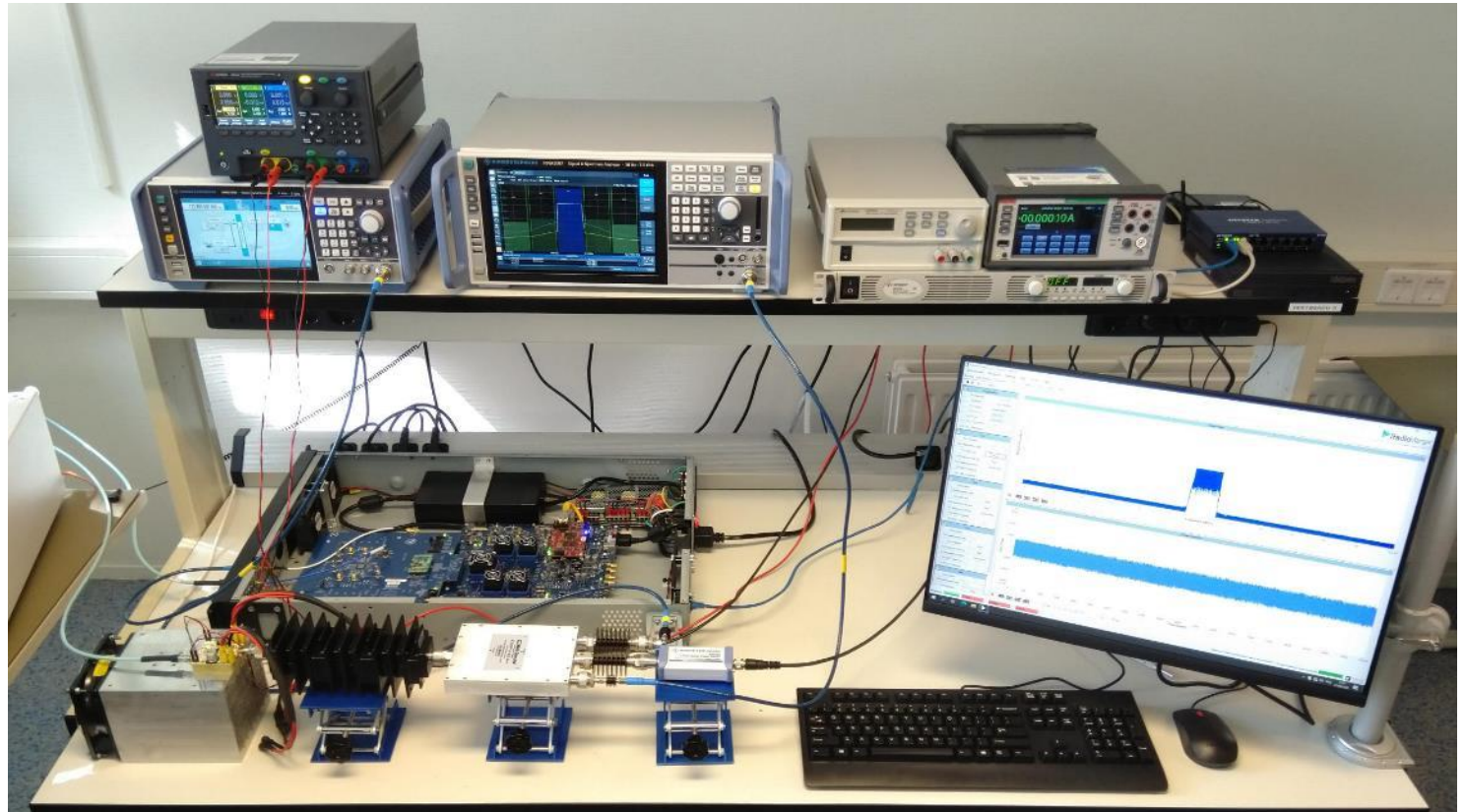
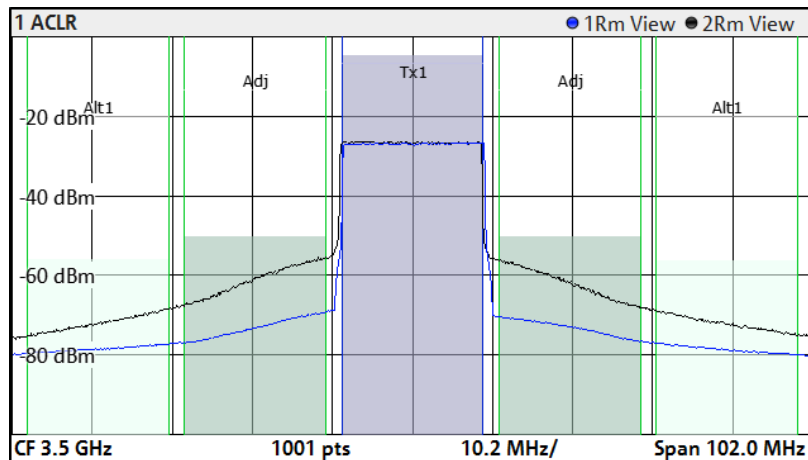


Digital Pre-Distortion

Realistic measurement



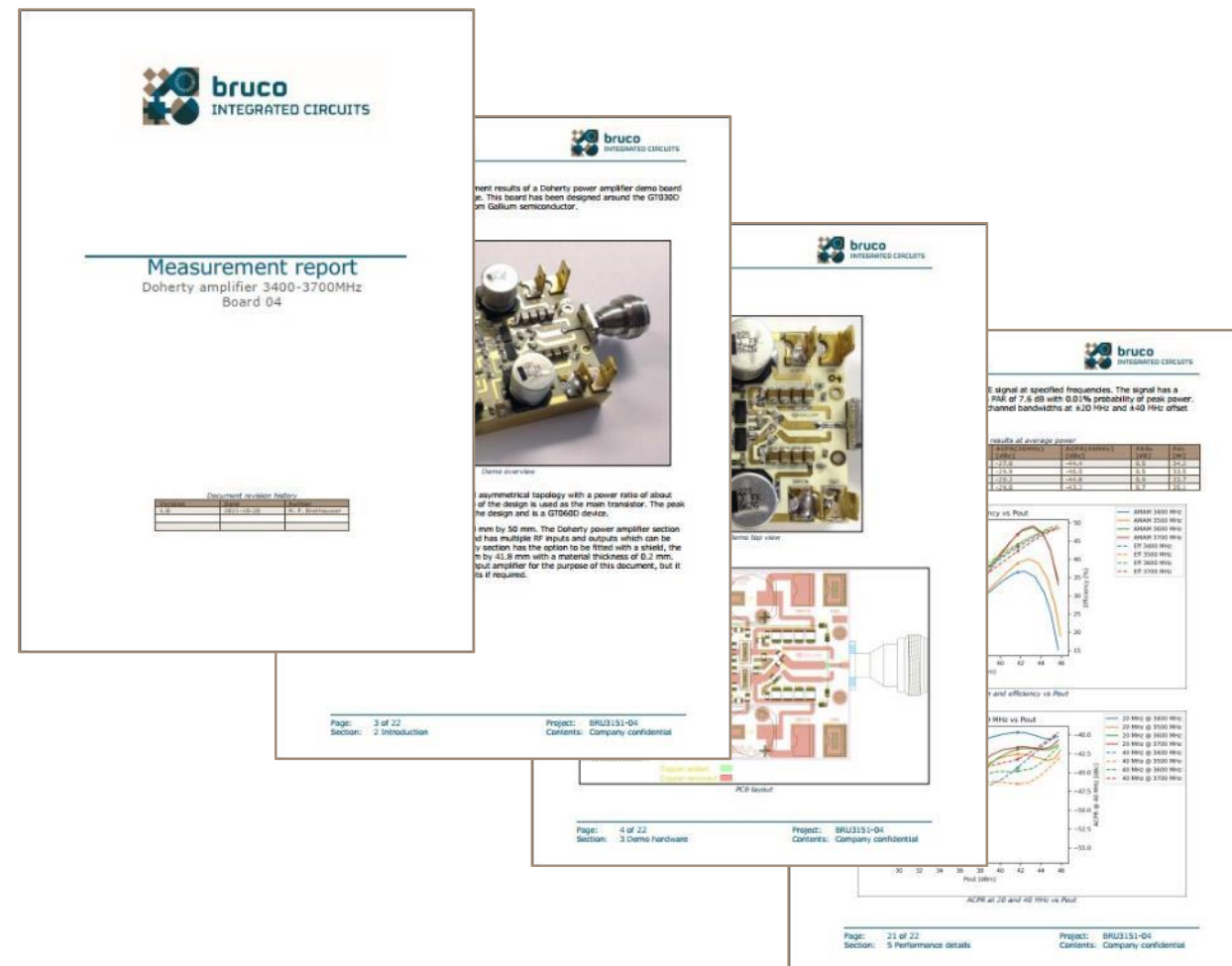
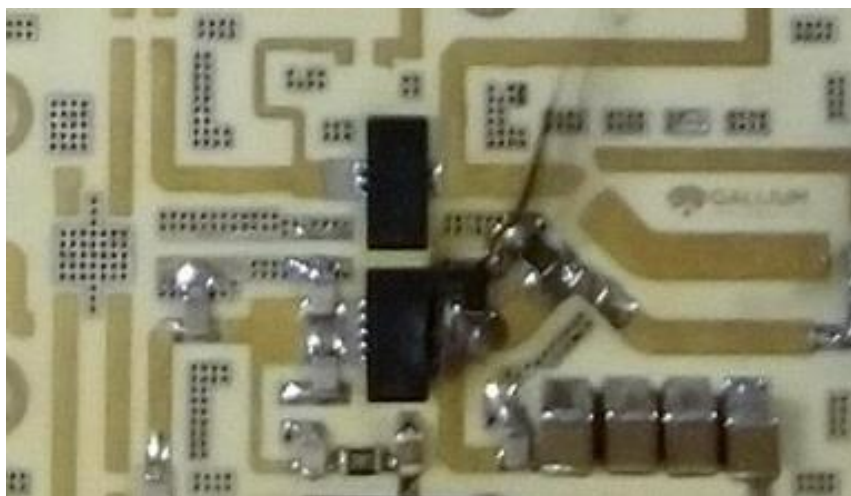
- Measurements to represent a realistic work environment
 - Specialist hardware
 - Accurate signals
 - Realistic algorithms
 - Monitoring of performance



Project ending

Deliverables

- Review specifications
 - Characterization
 - Make nice report
- Learn from mistakes

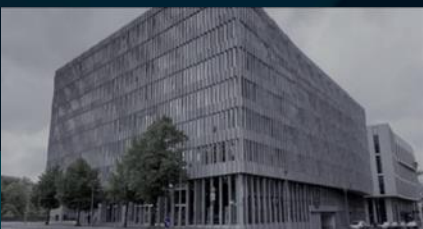




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Oostermaat 2
7623 CS Borne
The Netherlands
T +31 (0)74 2406 600
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