Optical links

Walter Beekman, Raditeq
(on behalf of C.N.Rood)

Introduction

- What is an optical link

- “An optical link is a communication connection that employs optical fibers to transmit data using light signals”

  ~Chat GPT

- Basically: It is just an expensive (coaxial) cable

Introduction

- Why use an optical link
  - Low losses

Table 2. Average Fiber Loss Table

Wavelength/ Mode	Fiber Core Diameter	Attenuation per Kilometer*	Attenuation per Splice	Attenuation Per Connector	Modal Bandwidth (MHz-km)
850 nm multi-mode	50 µm	2.40 dB	0.1 dB	0.75 dB	500
850 nm multi-mode	62.5/125 µm	3.00 dB	0.1 dB	0.75 dB	200
1300 nm multi-mode	50 µm	0.70 dB	0.1 dB	0.75 dB	500
1300 nm multi-mode	62.5/125 µm	0.75 dB	0.1 dB	0.75 dB	500
1310 nm single-mode	9 µm	0.35 dB	0.01 dB	0.75 dB	n/a
1550 nm single-mode	9 µm	0.22 dB	0.01 dB	0.75 dB	n/a

https://www.advantech.com/en/resources/white-papers/024e7c77-bc88-40f7-bc81-33c5a6d62dc3

Analogue laser

Digital data communication (BIDI)

  - No electrical connection
    - Immune to Radiated fields
    - Full isolation (Galvanically isolated)
    - No common mode currents
    - No oxidization

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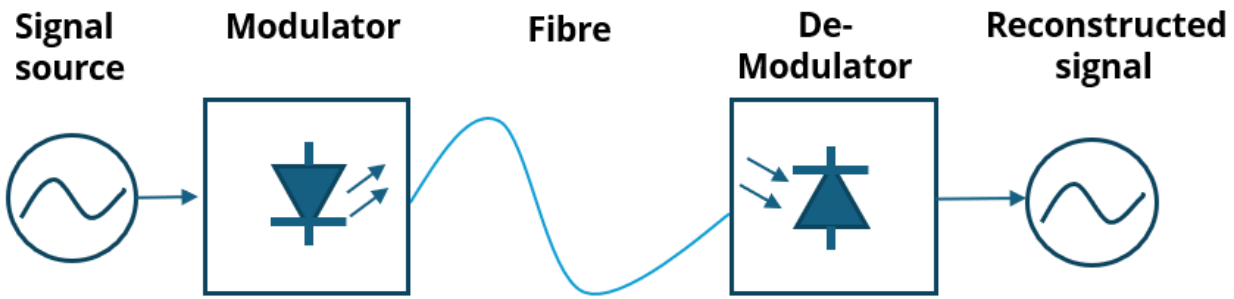
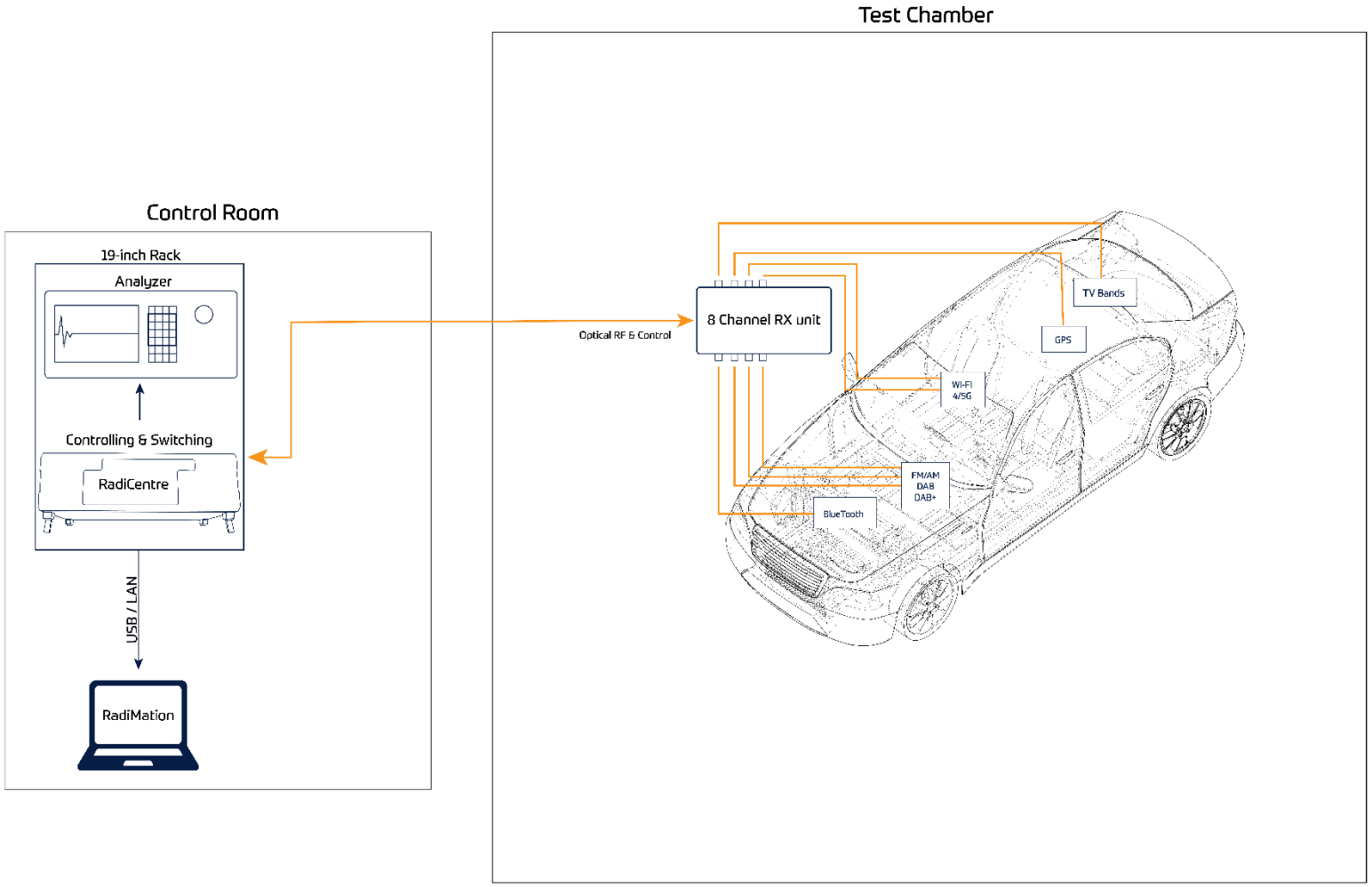
Introduction

- How does an optical link work



Applications



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Challenges

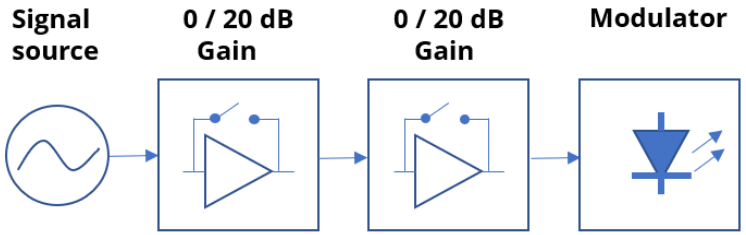
- Design
- RF routing
- Shielding
- Optical

Design challenges

- **Dynamic range**
  - Low noise floor for small signals
  - High compression for large signals

Design challenges

- Switchable amplifiers
  - 0, 20 and 40 dB gain



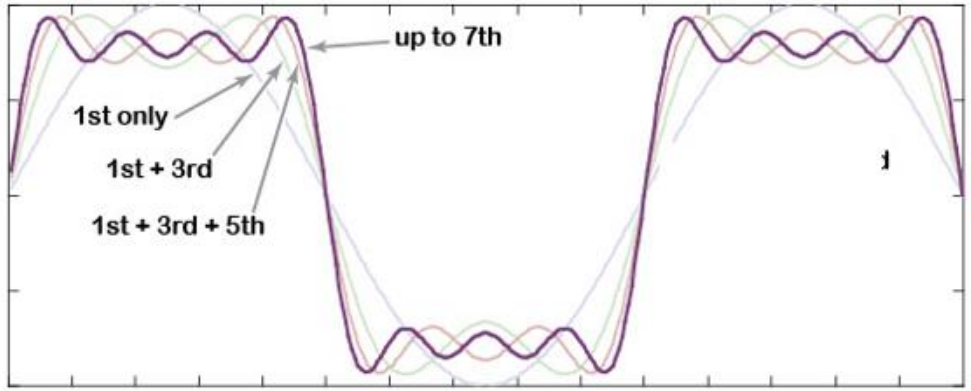
  - NF of >3dB (thermal noise floor)
  - P1dB <0dBm
- Instantaneous dynamic range 150dB
- Total dynamic range 170dB

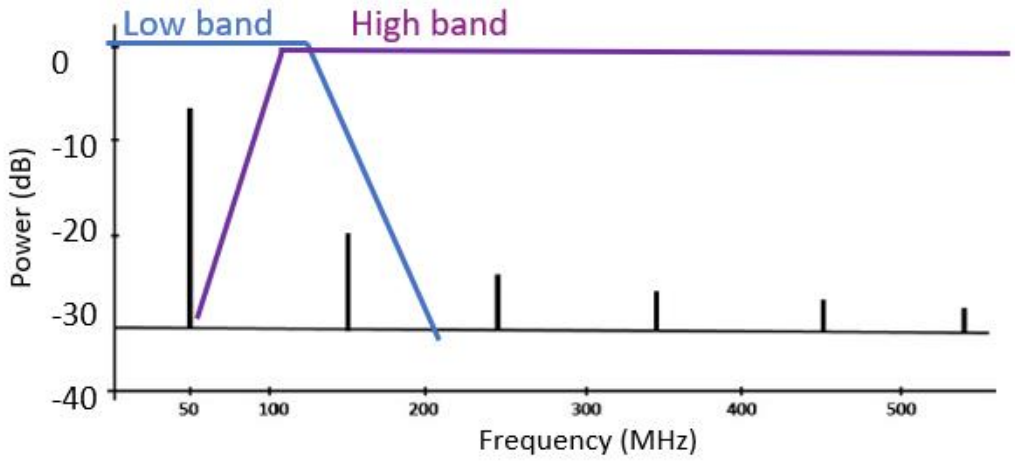
Design challenges

- **Wide instantaneous bandwidth**
  - No band switching (No low band / high band)
  - All signals follow the same RF stages
    - All the content at the input is present on the output
  - What will happen with a square wave?

Design challenges

- **Wide instantaneous bandwidth**

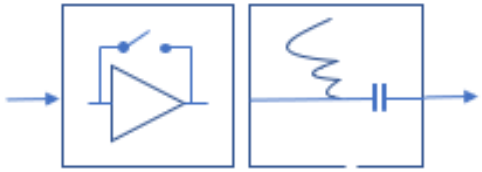




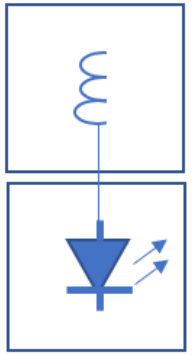
If band switching is used,
or system bandwidth is poor,
Measurement errors occur!

Design challenges

- **Wide instantaneous bandwidth**
- Selecting very broadband devices
- RF stages with complex bias Tee designs

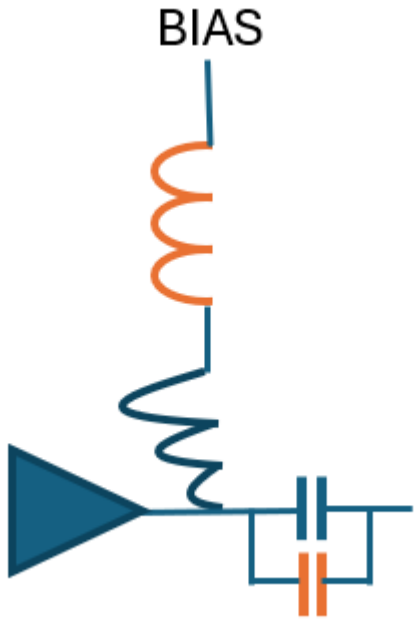


- Extending lasers LF response



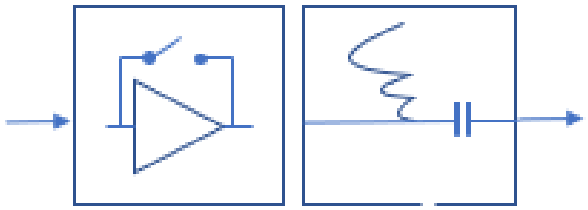
Design challenges

- **Complex bias Tee design**
  - HF: low parasitic capacitor and inductor
    - Small footprint low value C
    - Conical wire wound L
  - LF: High value capacitor and inductor
    - Low impedance capacitor @9kHz (ref to 50 ohms)
    - High impedance Inductor @9kHz (ref to 50 ohms)
  - The LF components may not influence the HF performance



Design challenges

- **Bias Tee inductive load protection**
- Gain switching
  - Gain state draws ~70mA
  - Trough state draws ~1mA
- Energy storage
  - 10mH inductor
  - 10uF coupling caps
- Large transients on RF trace >> damaging the amplifier!



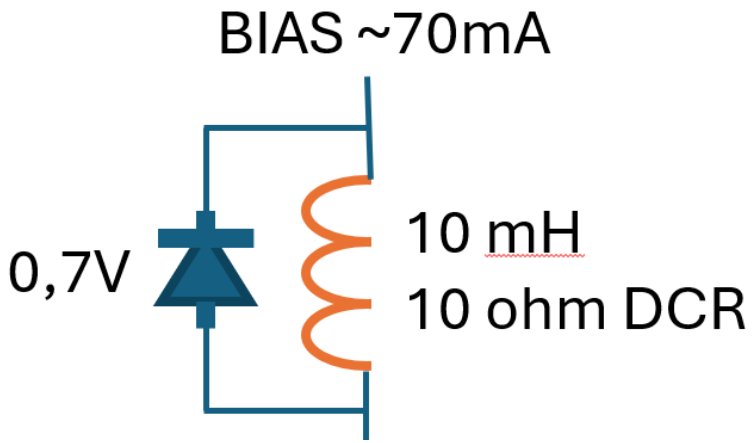
Design challenges

- **Clamping diodes**
- Can not influence the RF performance
  - Very small footprint
  - Very small input capacitance
  - Large breakdown voltage

  >> Not available

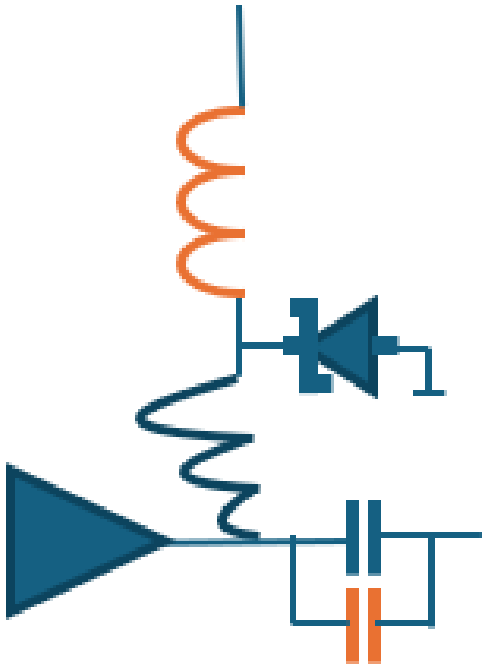
Design challenges

- **“simple” flyback diode**
  - DC loss will bias the diode
  - Creating a lower impedant path



Design challenges

- **Solution**

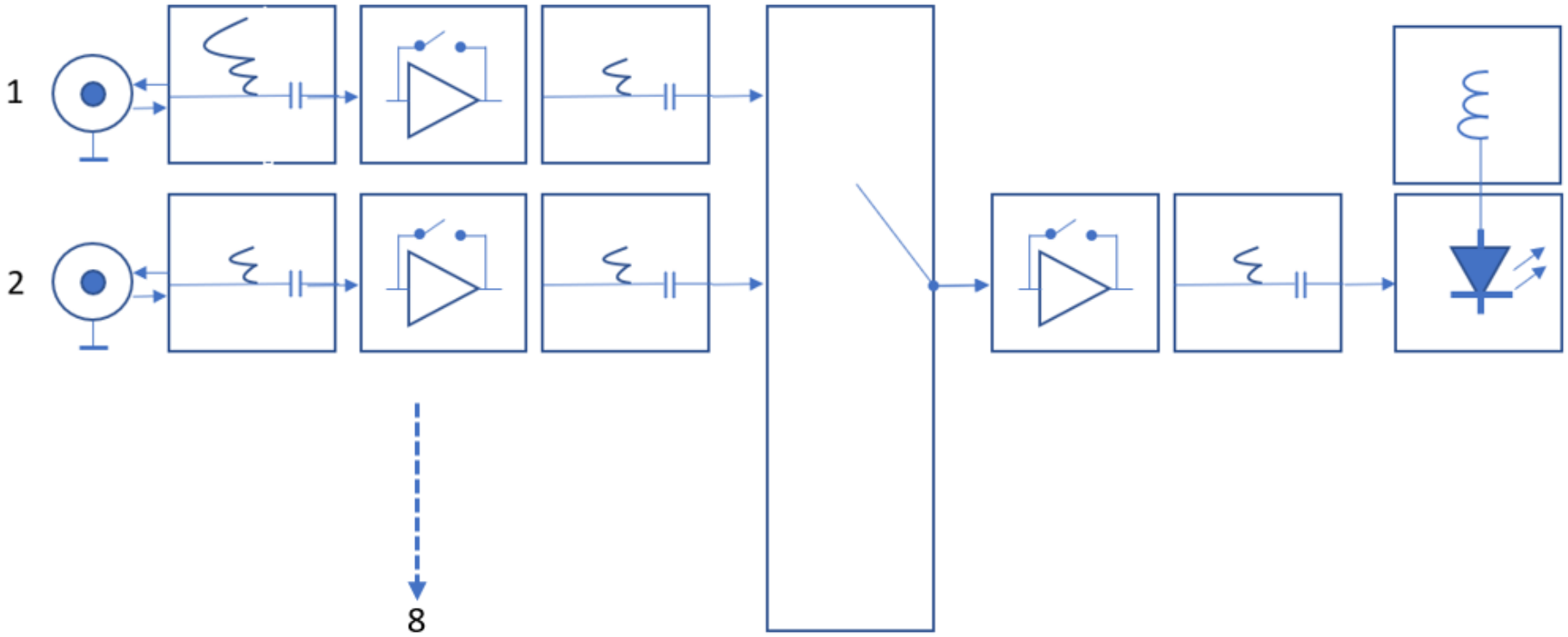


Design challenges

- **Multiple channels**
- Multiple antennae in a car
- Setup different measurements in 1 go
- 1 RF channel, all phantom power

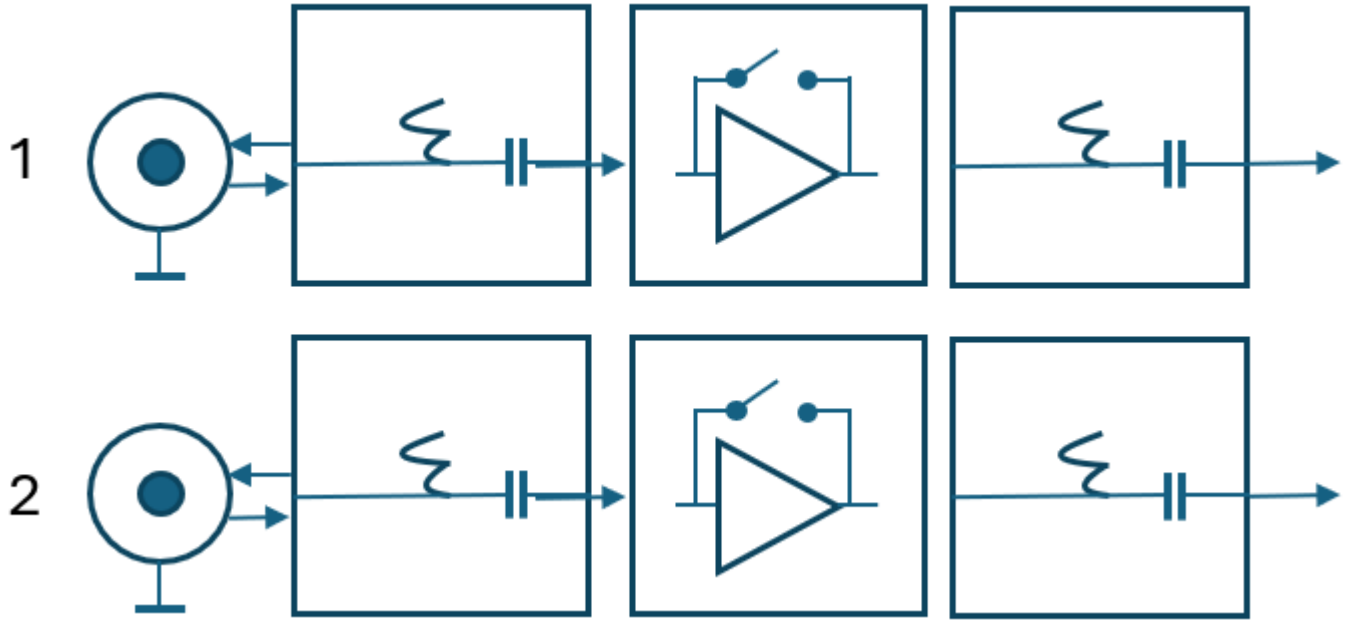
Design challenges

- **8 channels**



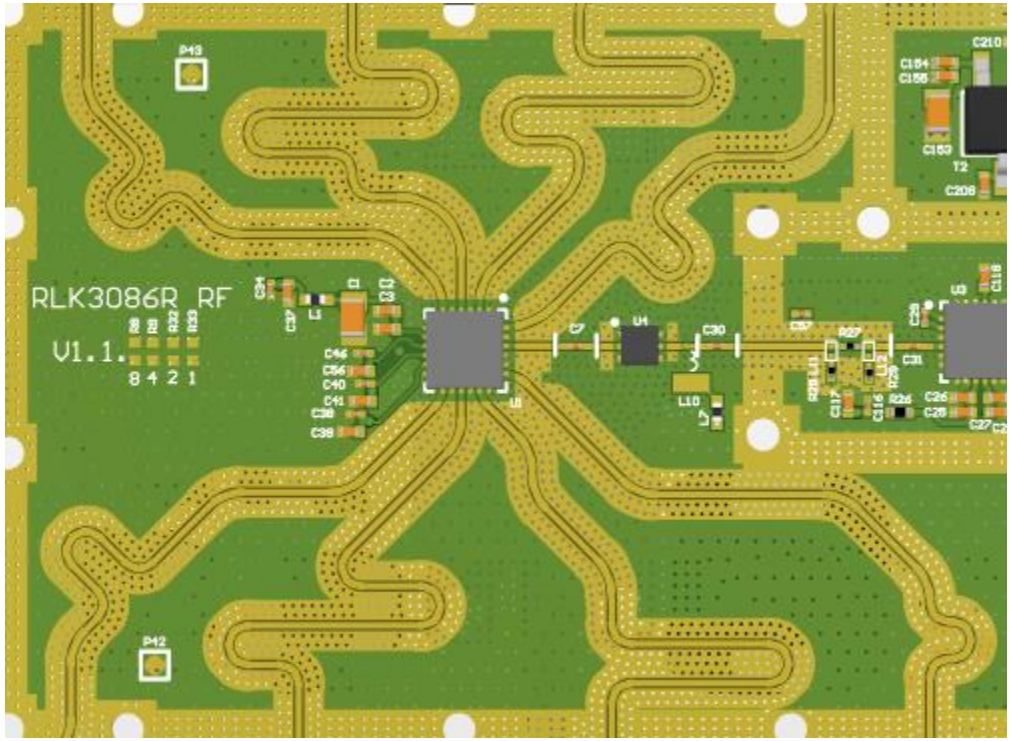
RF routing challenges

- **High isolation** (no disturbance from other channels)
  - Large magnetic fields in bias tees
    - Minimize magnetic coupling in the inductors
  - Turn off Rf amplifiers in non-used paths



RF routing challenges

- **tracking between channels**
  - Length matching all the RF traces
  - Same bend radius on all traces



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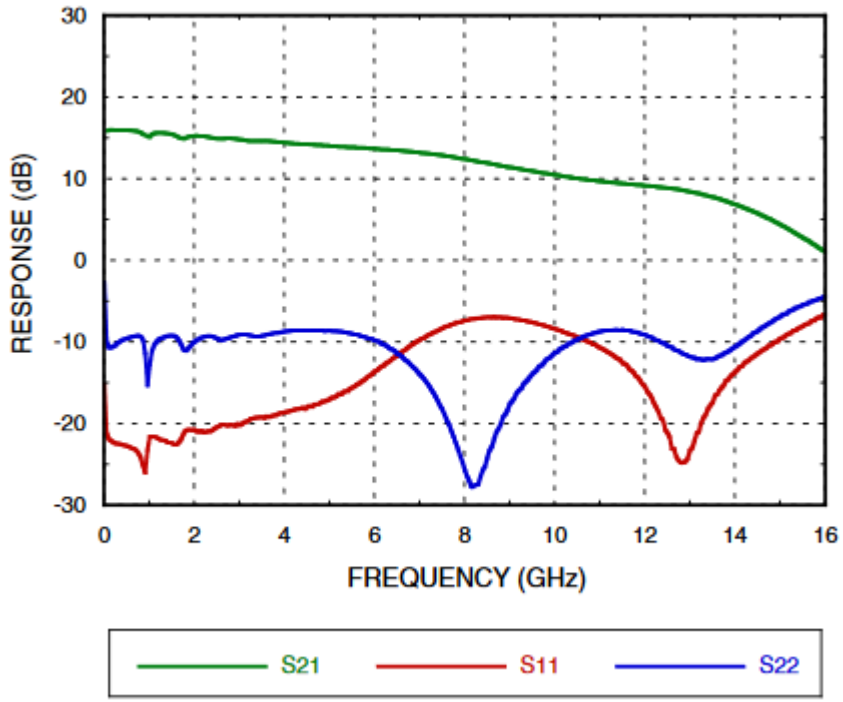
RF routing challenges

- **Flat frequency response**
- Multiple RF devices
  - High LF gain
  - Lower HF gain
- Trace losses
  - Low loss LF
  - High loss HF



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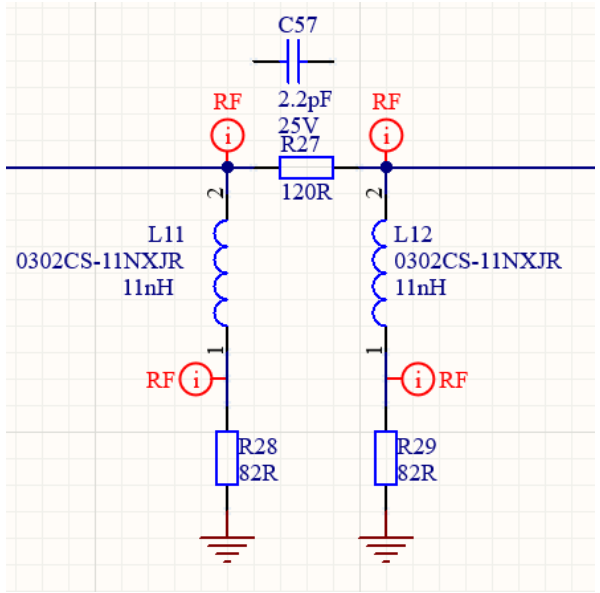
RF routing challenges

- **Frequency response correction**
- Gain equalizer design
  - PI attenuator design >> attenuate LF response
  - LCL high pass filter design >> minimize effect on the HF response



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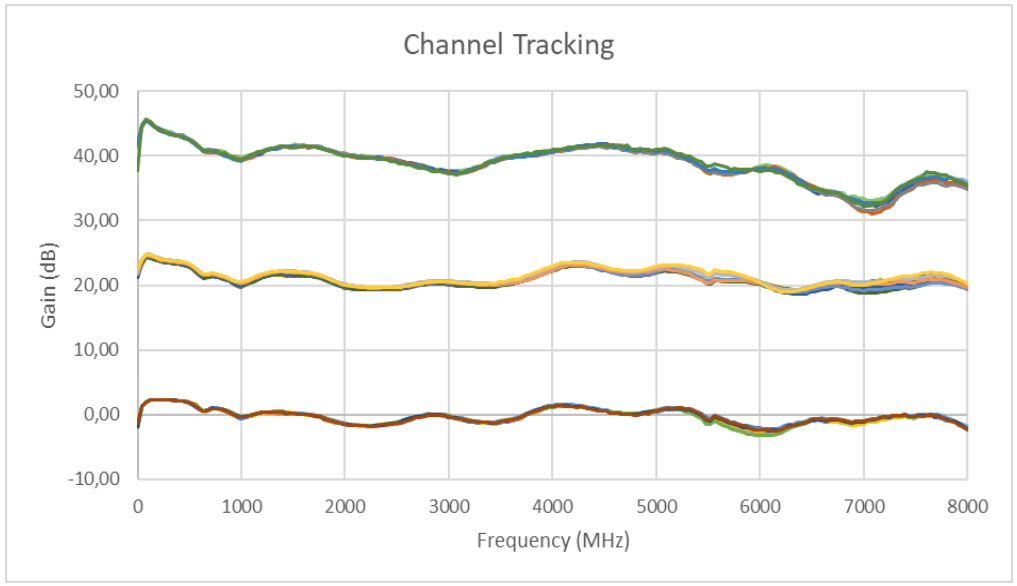
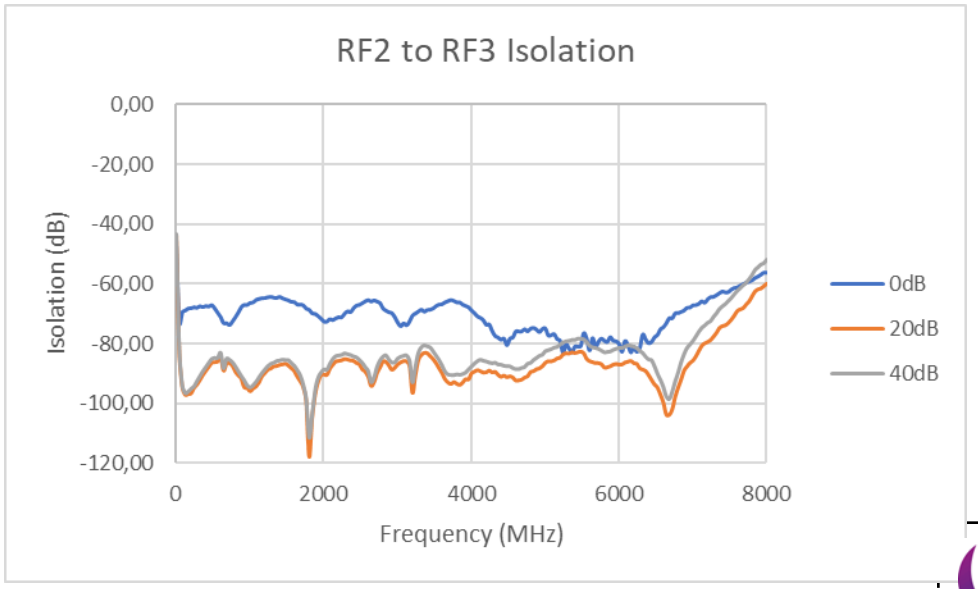
RF routing results

- **Frequency response correction**





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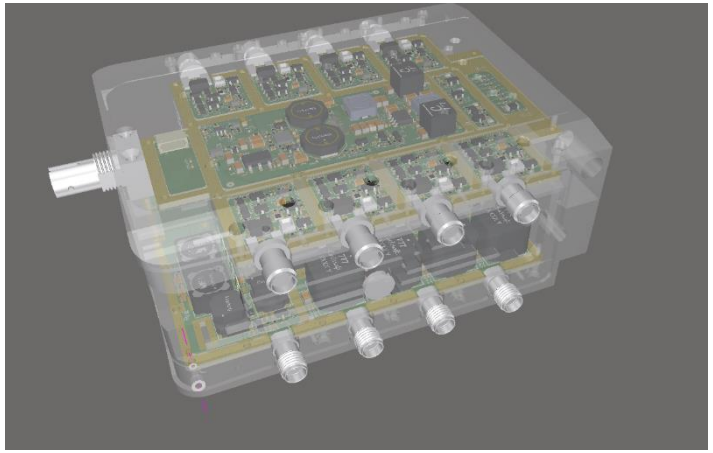
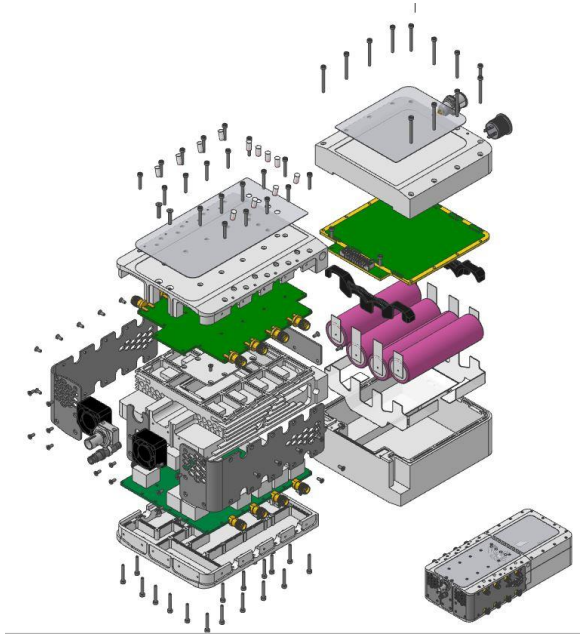
Shielding challenges

- **Shielded & compact**
- External shielding
  - Shield system from external (high) field strengths
  - Prevent radiation in the environment
- Internal shielding
  - Shield internal parts from each other
    - sensitive RF board
    - Power supplies
    - Processor
    - Communication

Shielding challenges

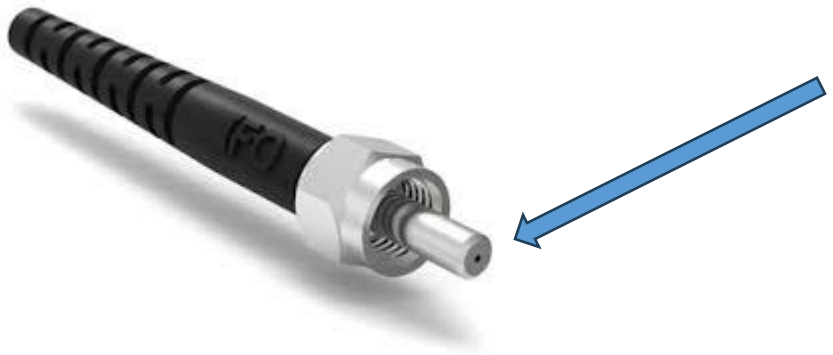
- **Shielding compartments**





Optical challenges

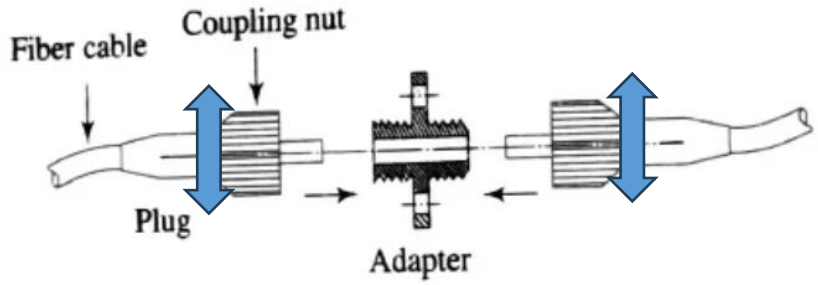
- **Fibre alignment**
- Small fibre core



9 micrometer!

Optical challenges

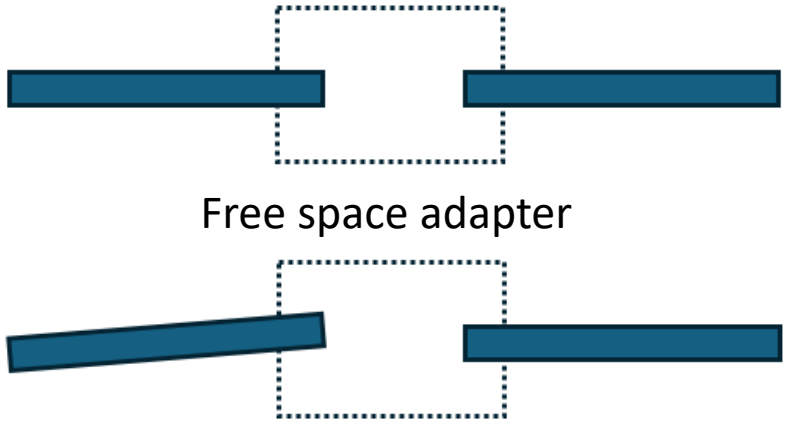
- **Fibre alignment**
- **Tolerance in tread**
  - Slight tilt between coupling nut and adapter
  - Miss alignment



https://electronics-club.com/optical-fiber-connector-and-types/

Optical challenges

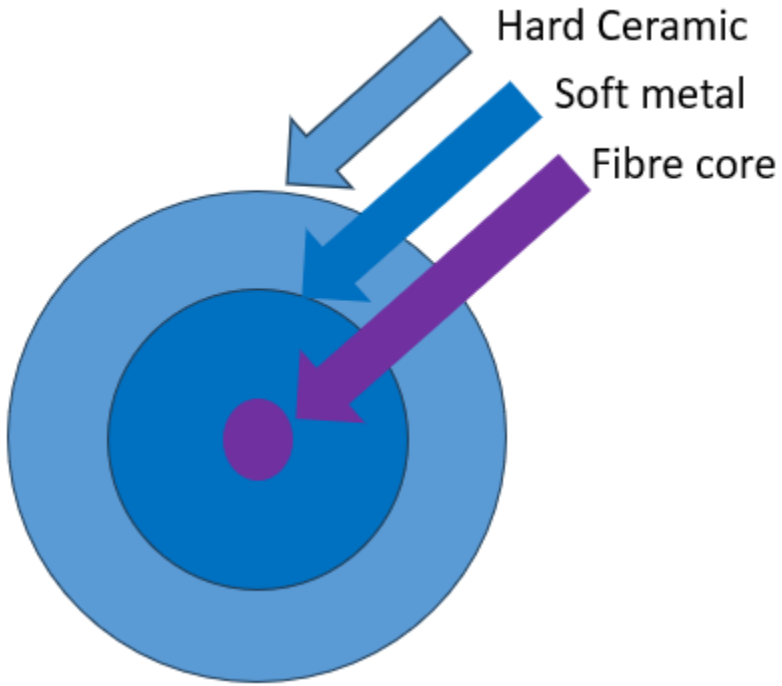
- **Fibre alignment**
- Tolerance in tread
  - Offset the internal fibre alignment



  - Not all light is sent in the receiving fibre >>over 10dB extra IL!

Optical challenges

- **Fibre alignment solution**
  - Strain relief the fibre from the ceramic



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Master slave optical link

- Master slave principle
- Each module can be the master or slaveunit
  - Receive RF from the EUT over fibre
  - Send RF to the EUT over fibre

- With 2 sets you can build a full bidirectional analogue link

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