Final presentation

European Space Agency
OSIP Open Channel
Early Technology Development Activities Evaluation
Session 2020-03 Contract 400013260020NLGLC

Miniaturised distributed optical fibre sensors (DOFS) based on photonic integrated circuits (PICs) for space applications.

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Objectives

Investigate the use of photonic integrated circuits (PIC) as an optical engine in distributed fibre-optic sensors (DFOS).

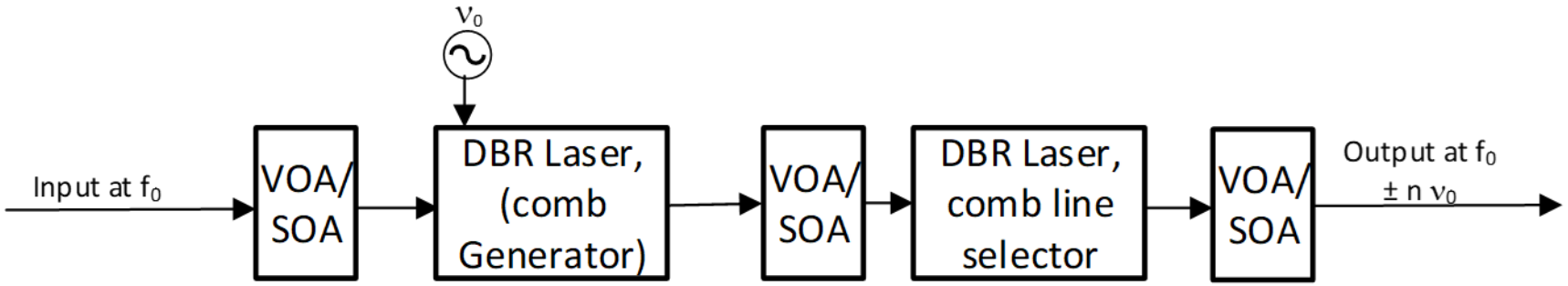
Proof of concept PIC to provide frequency shifting and intensity modulation

Phase 1: design and procurement of suitable PICs, design and implementation of a packaging solution, design and assembly of dedicated control electronics

Phase 2: Evaluation of the PIC performance

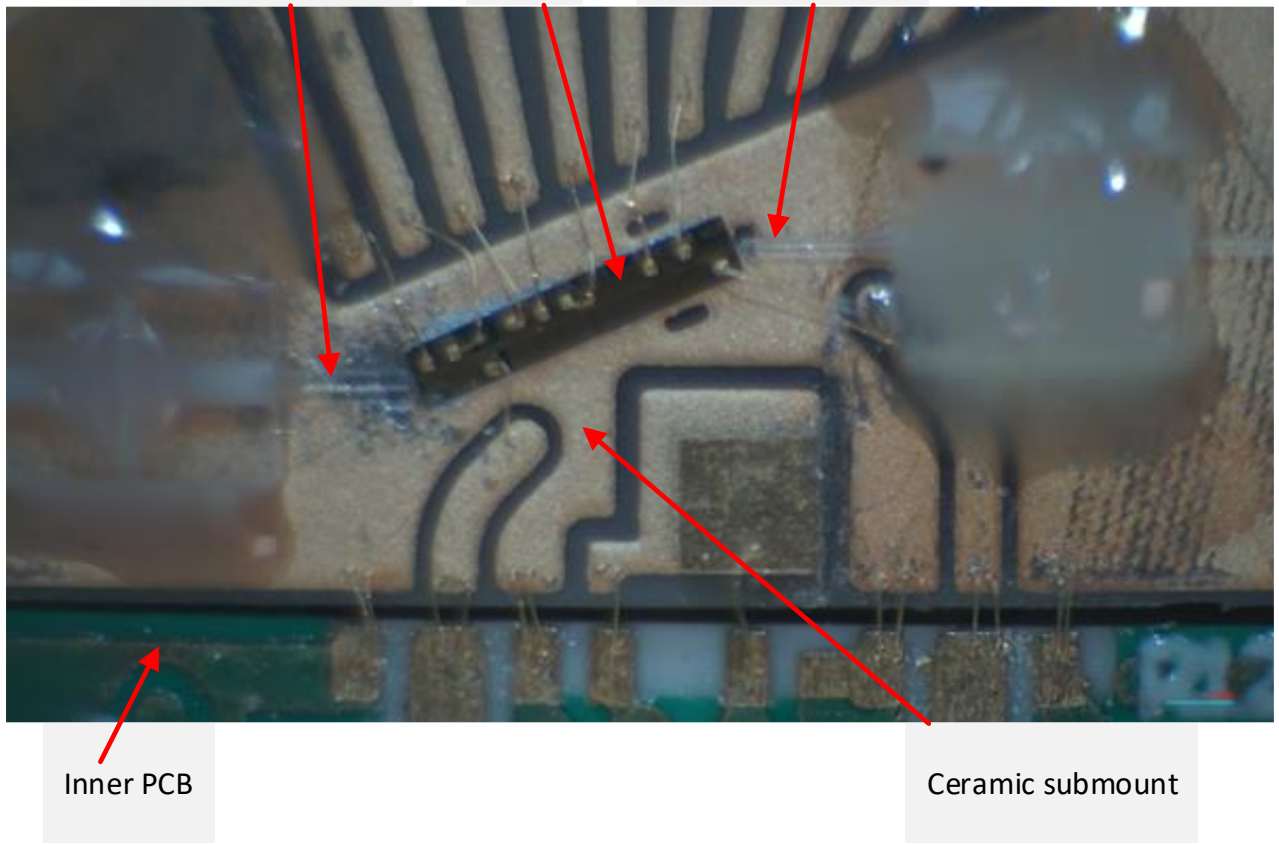
Phase 3: proof of concept in a DFOS set up.

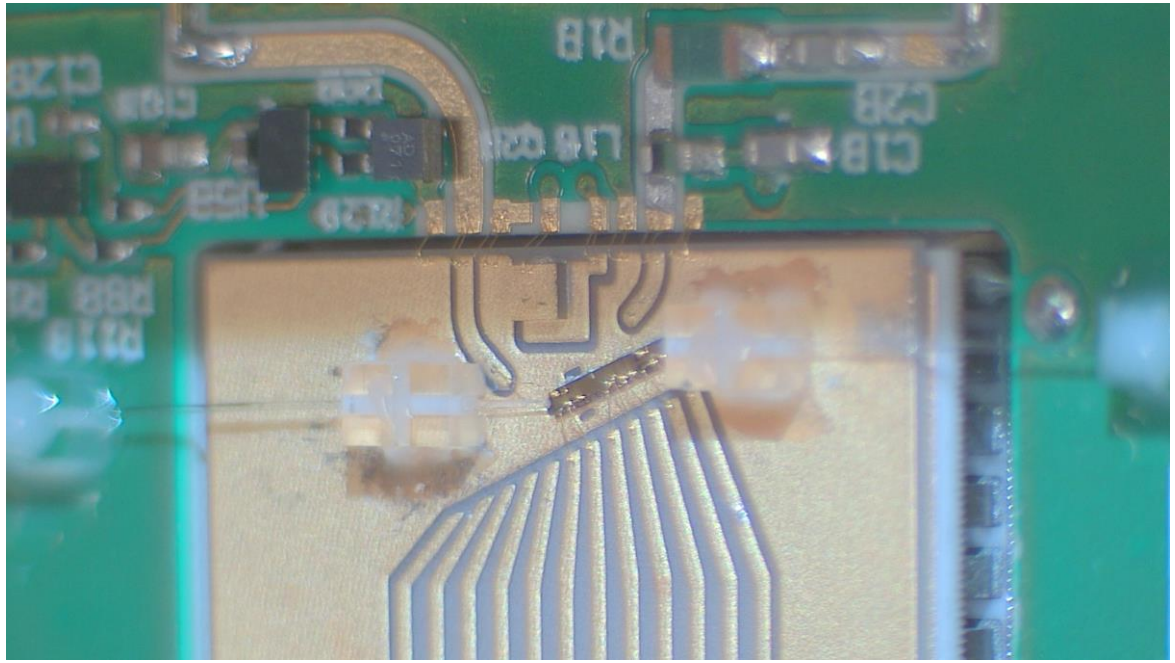
General approach



1. Convert input light into frequency comb internal to PIC (Comb generator laser)
2. Select one line of the comb by injection-locking 2nd internal laser (Comb line selector)
3. Intensity modulation using the final semiconductor optical amplifier (SOA) acting as a variable optical attenuator (VOA)

Phase 1: PIC in packaging





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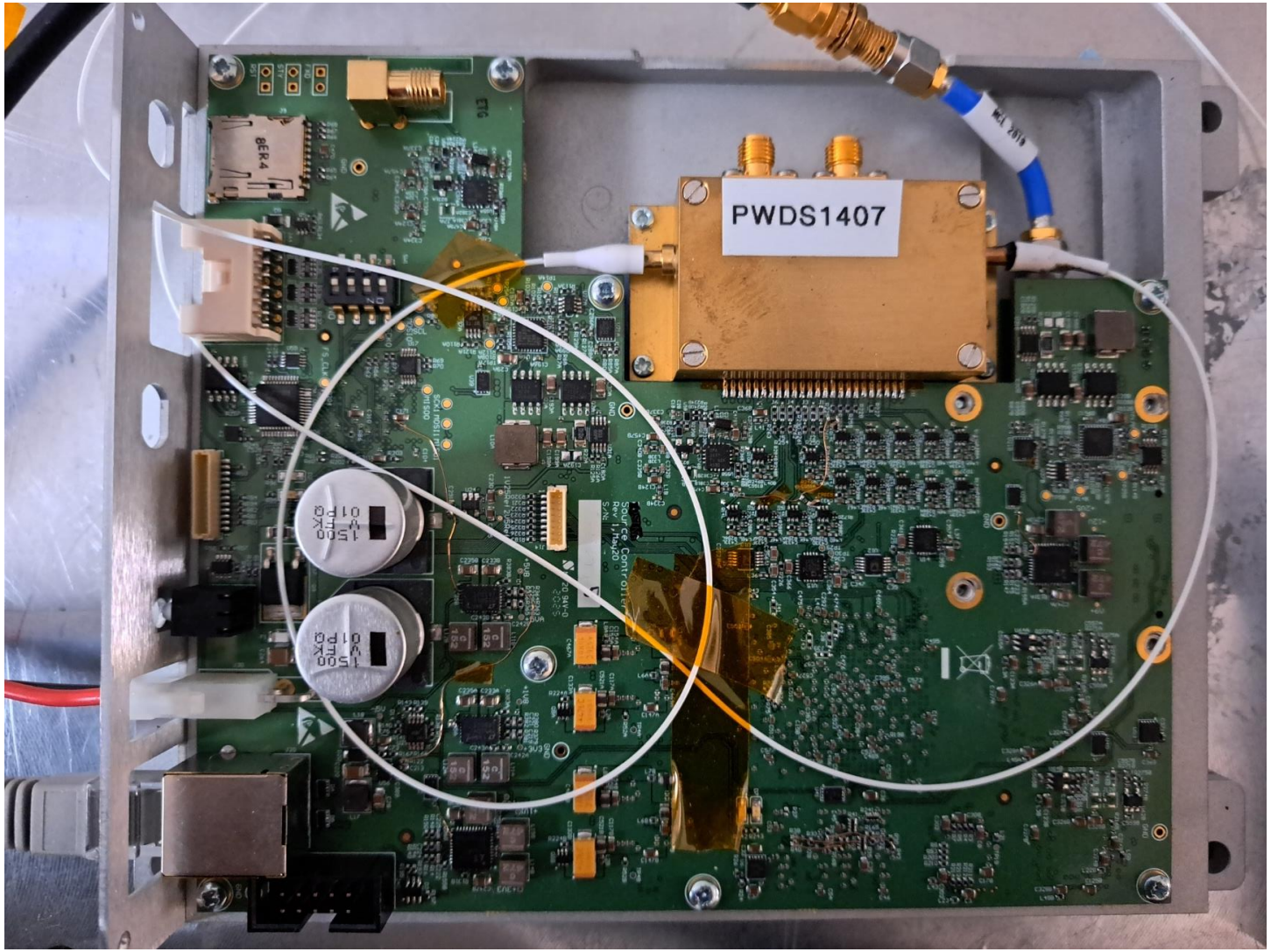
Phase 1: Packaged PIC with control electronics



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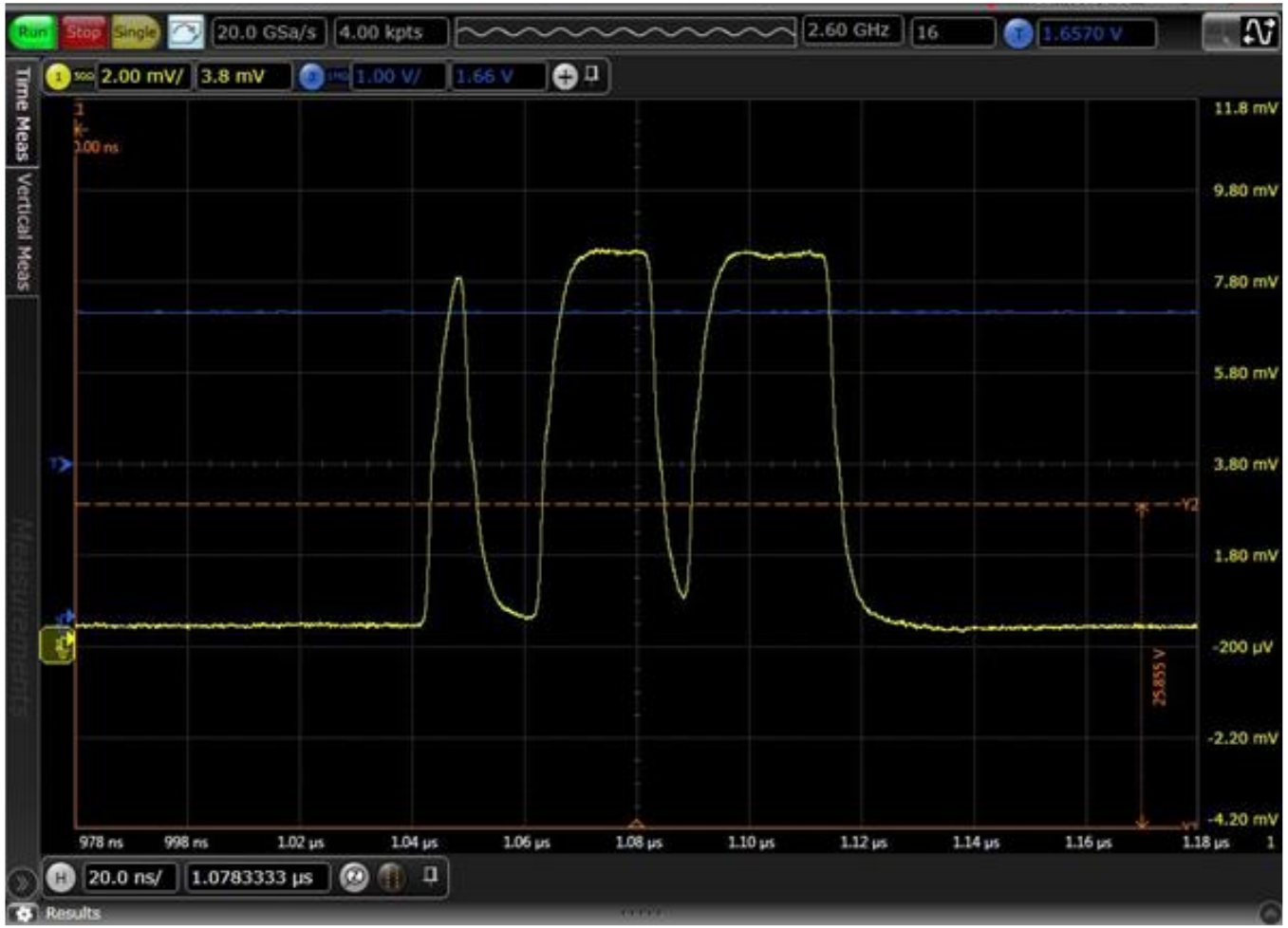
Phase 2: power modulation



- ~ 7 ns rise/fall time: good enough for application
- Extinction ratio: 50: 1 Insufficient for application.

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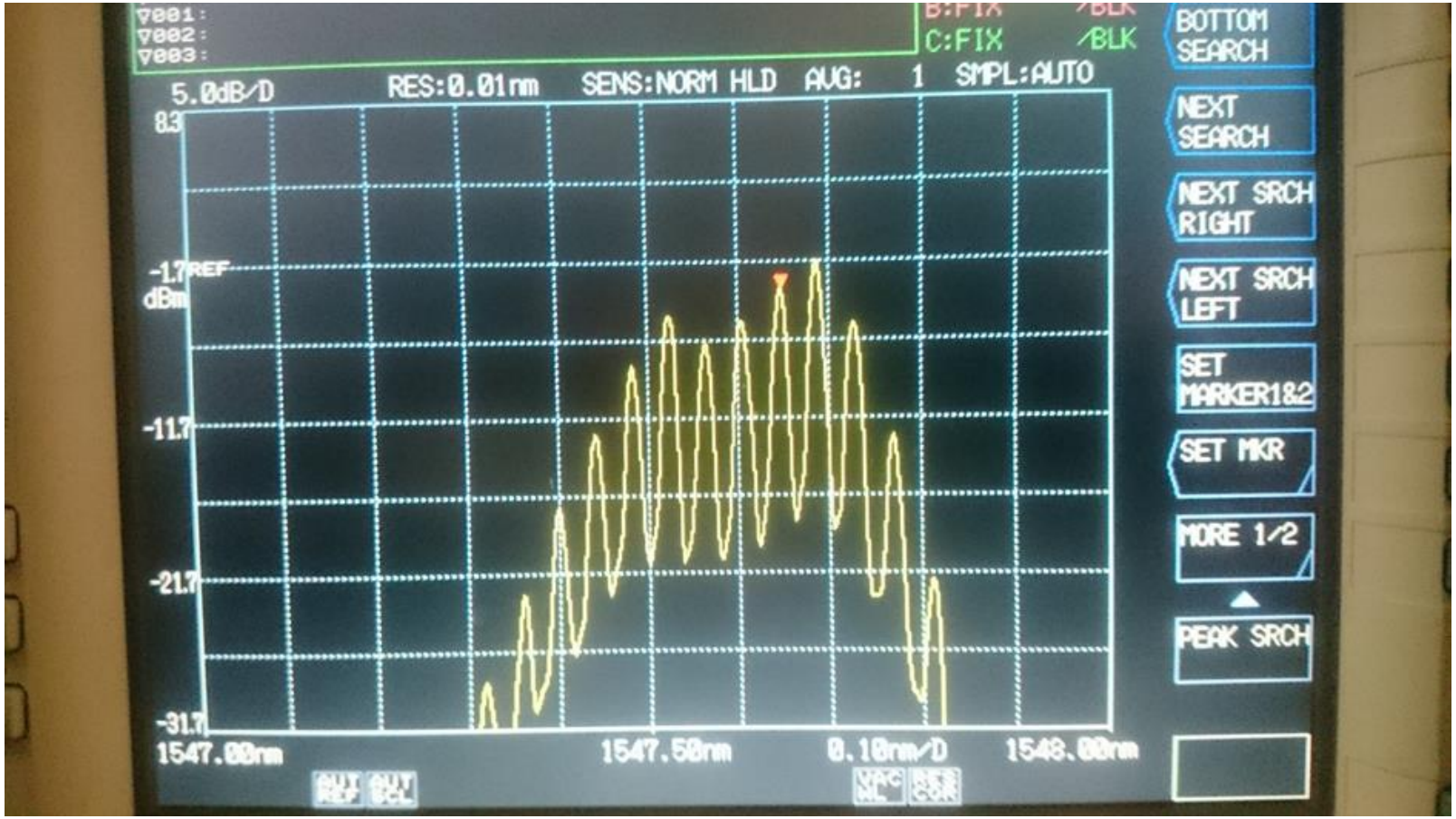
Phase 2: reflected comb



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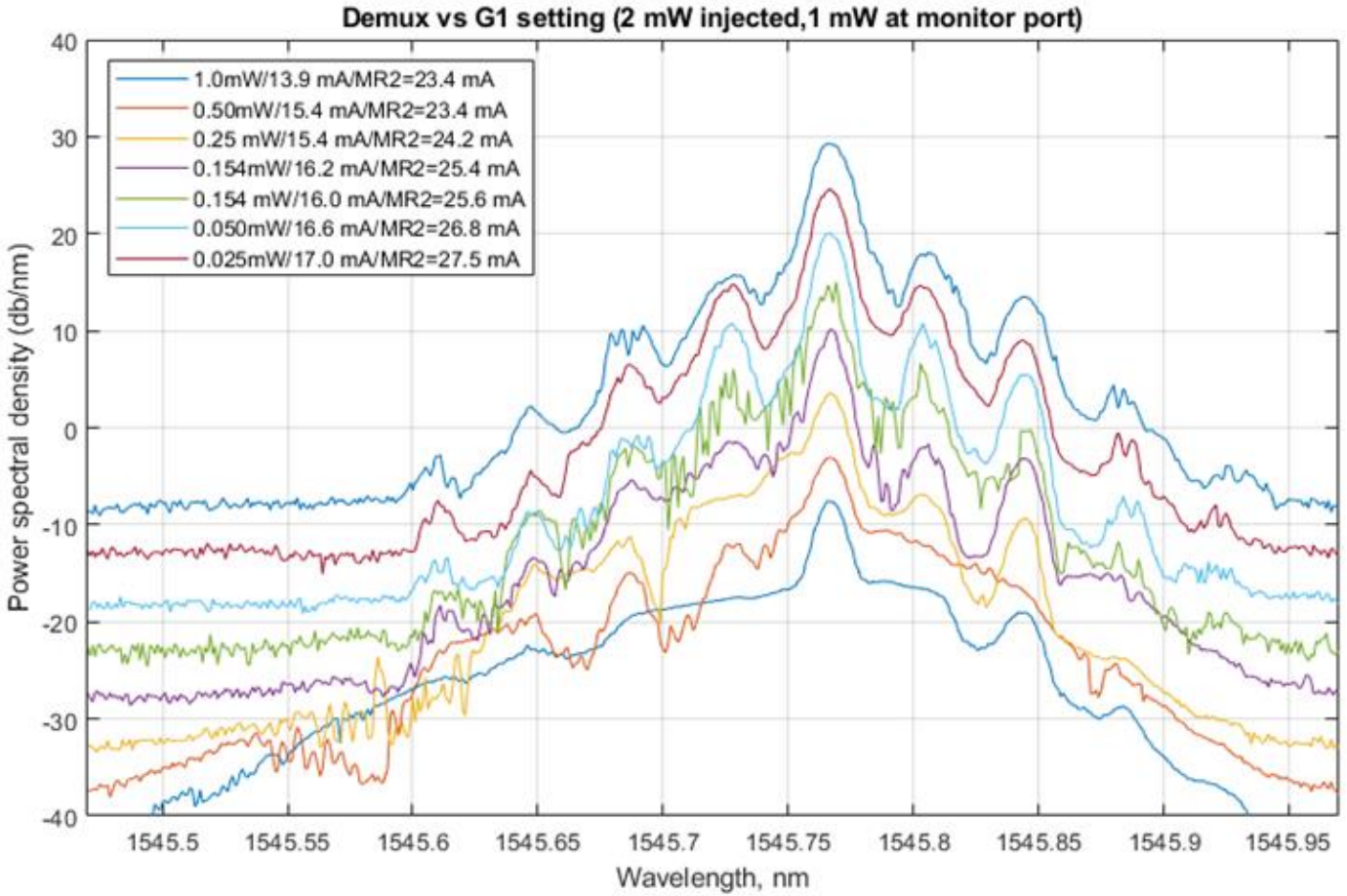
Phase 2: comb line selection



<12 dB Rejection

Concept proven but performance inadequate

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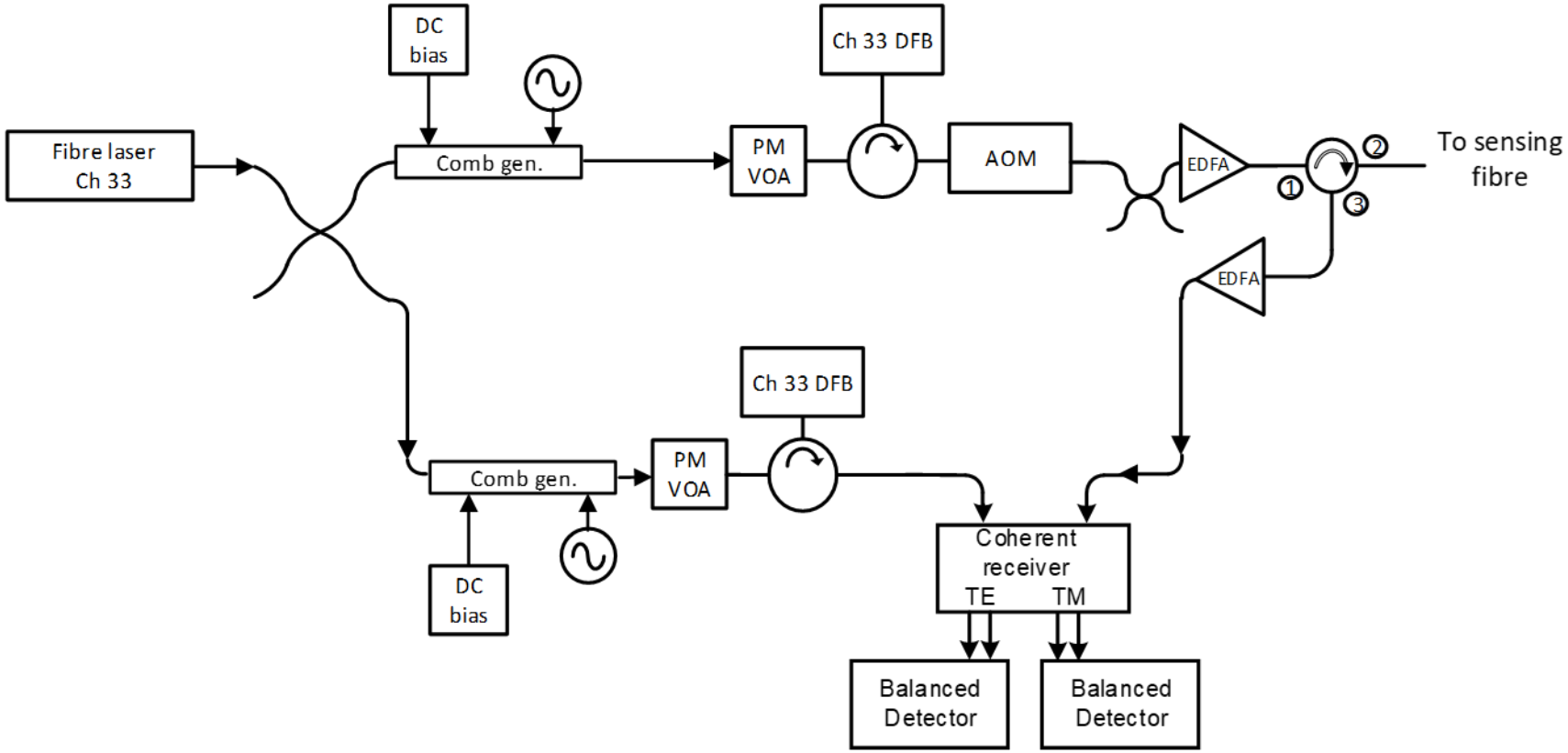
Conclusions from Phase 2

- Basic principles proven:
  - locking comb generator to external source
  - Generating frequency comb
  - Selecting comb line by injection-locking a second laser
  - Modulating output power using SOA
- But performance insufficient for demonstration

➢Principles of the DFOS measurement to be proven using the same principles with discrete devices

Optical set up for Phase 3



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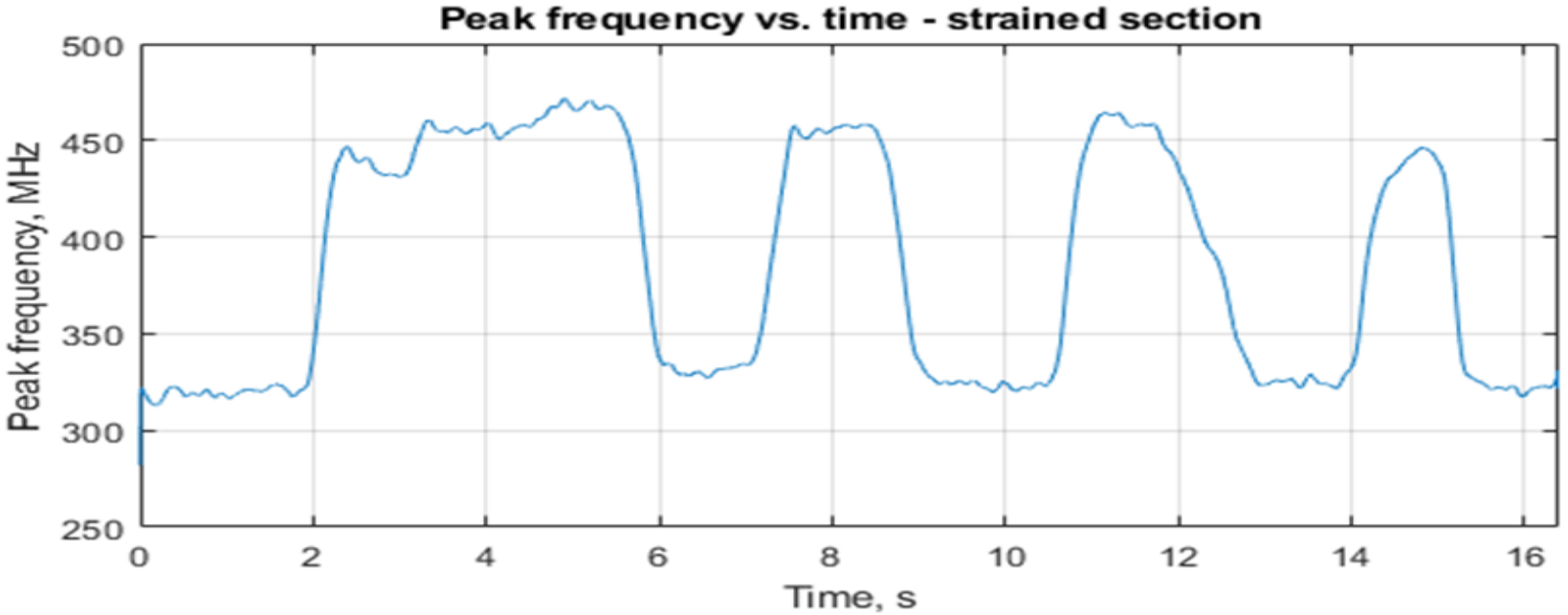
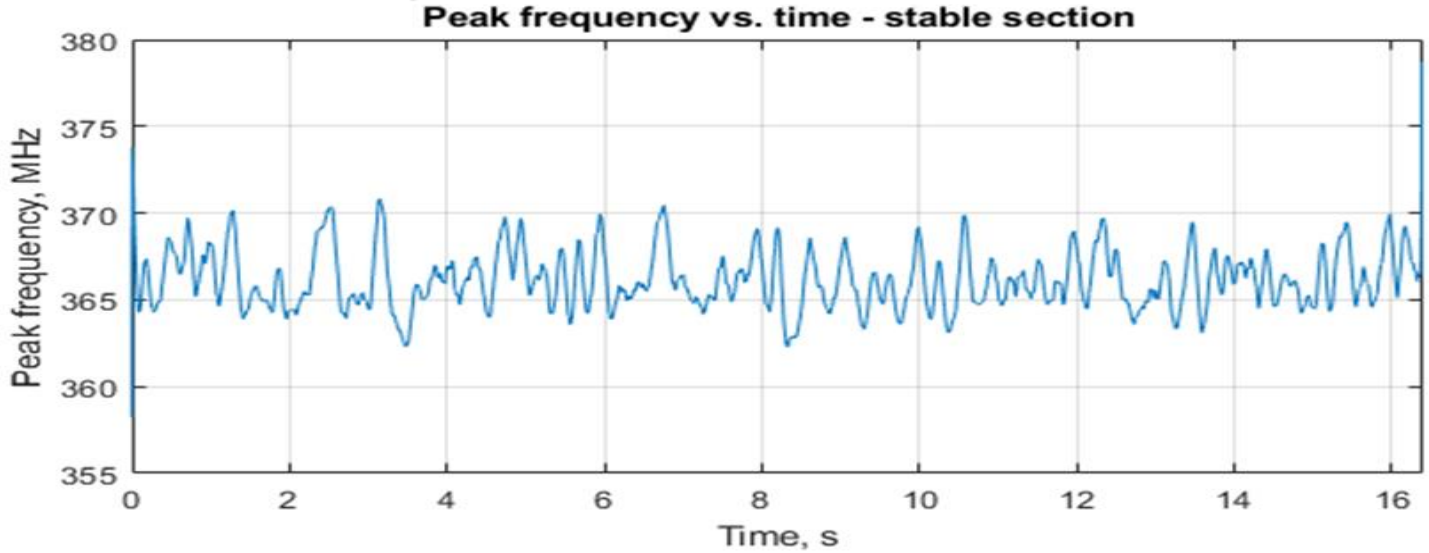
Phase 3: BOTDR strain measurement





- @ 100 ms update rate:
- 1.66 MHz r.m.s.
- Equivalent to ~ 33 με/ 1.67 K

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Conclusions

1. Prototype PICs manufactured and packaged
2. Suitable control electronics designed, built and tested.
3. Evaluation of the PIC demonstrated the concept, but not the required performance.
4. Proof of concept in a DFOS setup therefore prototyped with discrete components and successfully tested for Brillouin OTDR and DAS

Initial TRL: 1 Final TRL: 3

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