## Contents

1 Introduction ................................................................. 1
   1.1 Distributed fiber optics sensors .................................... 3
   1.2 Thesis objectives .................................................. 5
   1.3 Structure of the thesis ............................................. 6
   References ...................................................................... 10

2 Time-frequency domain analysis for long fiber Bragg grating sensing applications .... 11
   2.1 Introduction .......................................................... 11
   2.2 Principle of operation ............................................... 13
   2.3 Fiber optic sensors using a 10 cm-long high reflectivity FBG ........... 16
      2.3.1 Liquid level sensor .............................................. 16
      2.3.2 Temperature gradient sensor .................................. 20
   2.4 Spot event detection along a large scale sensor based on ultra weak FBGs .... 23
      2.4.1 Experimental measurements and results ....................... 25
      2.4.2 Sensor performances ........................................... 29
   2.5 Conclusions .......................................................... 32
   References ...................................................................... 37

3 Long FBGs-based sensors interrogating using microwave photonics filtering techniques 39
   3.1 Introduction .......................................................... 39
   3.2 Principle of operation ............................................... 41
   3.3 Experimental measurements and results ................................ 44
      3.3.1 High reflectivity FBG sensor interrogation .................... 45
      3.3.2 Weak FBGs-based sensor interrogation ........................ 49
      3.3.3 Large scale sensor network based on 500 ultra weak FBGs .... 53
   3.4 Conclusions .......................................................... 61
   References ...................................................................... 64

4 Fiber optic sensors using long period gratings ................................................. 65
   4.1 Introduction .......................................................... 65
   4.2 LPGs fabrication and characteristics ................................... 66
### 4.3 Liquid level sensor based on a LPG and MWP technique

- **4.3.1 Description of the method**
- **4.3.2 Experimental measurements and results**

### 4.4 RH and temperature sensor based on half-coated LPG

### 4.5 Conclusions

### References

### 5 Improving the signal response of BOTDA systems by the aid of fiber Bragg gratings

- **5.1 Introduction**
- **5.2 Principle of operation**
  - 5.2.1 Spontaneous and stimulated scattering in optical fibers
  - 5.2.2 Brillouin scattering
  - 5.2.3 Brillouin optical time-domain analysis
- **5.3 Proposed method based on a multi-frequency pump-probe Brillouin interaction**
  - 5.3.1 Spectral allocation of pump and probe signals
- **5.4 FBG array characteristics and tuning method**
- **5.5 Description of the sensing method and experimental setup**
- **5.6 Experimental measurements and results**
  - 5.6.1 Sensor response
  - 5.6.2 Brillouin gain spectrum and frequency uncertainty
  - 5.6.3 Spatial resolution
  - 5.6.4 Pump depletion
- **5.7 Conclusions**

### References

### 6 Conclusions and future perspectives

- **6.1 Summary and overall conclusions**
- **6.2 Direction for future research**

### References

### A Publications

- **A.1 Journal**
- **A.2 Conference**

### B Other publications

- **B.1 Journal**
- **B.2 Conference**