UNIVERSITY OF SOUTHAMPTON

A Study of a Correlation Spectroscopy Gas Detection Method

by

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ABSTRACT

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The study of an optical correlation spectroscopy gas detection system is presented in this thesis. The correlation spectroscopy method uses a sample of reference gas as a filter to identify the concentration of the target gas in a measurement gas cell.

A review of optical gas sensing methods employed throughout the twentieth and early twenty-first centuries, which led to this version of correlation spectroscopy, is presented. The equation for the output signal modulation, the modulation index, is derived. The method of correlation spectroscopy is analysed by simplified approximation, which aids the understanding of the method.

The study primarily relates to the detection of CO_2 gas. The 2000 edition of the Hitran database was used to provide spectroscopic absorption data for a series of simulations of the correlation spectroscopy method. The simulations show the dependence of the modulation index on measurement cell target gas concentration, measurement cell target gas pressure and measurement cell target gas temperature. Experiments were carried out to assess the correlation spectroscopy method. These experiments used a large-core optical fibre implementation of a correlation spectroscopy detection system with LED infra-red optical sources. A comparison of simulated and experimental results is given. At gas cell pressures of 1 bar the experimental data and the simulated data were found to agree to within 15%. Simulated results for the detection of CH_4 and O_2 are also presented.

A method of increasing the output modulation index by the pressurisation of a CO_2 containing reference gas cell was also investigated by simulation and experiment. It was found by experiment and simulation, that by the pressurisation of the reference gas cell to 6 bar, the modulation index could by increased by up to a factor of 2. However, it was shown that the cross-sensitivity to a contaminant gas also increased.

Keywords: correlation spectroscopy, gas filter correlation, gas detection, infra-red gas detection, optical fibre sensor, carbon dioxide, methane, oxygen.

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Declaration of Authorship

I, **Paul Chambers**, declare that the thesis entitled:

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and the work presented in it, are my own.

I confirm that:

- this work was done wholly or mainly while in candidature for a research degree at this University;
- where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
- where I have consulted the published work of others, this is always clearly attributed;
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- I have acknowledged all main sources of help;
- where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
- parts of this work have been published in the publications listed in Appendix B.

Signed: Paul Chambers

Date: 17/10/2005

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