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Predicted response of optical gas sensing systems using correlation spectroscopy for combustion monitoring

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To control combustion systems it is advantageous to monitor O_2, CO_2 and CH_4 concentration levels. One desirable approach could be correlation spectroscopy, an optical gas detection system which uses the absorption spectrum of the target gas to make measurements.

Correlation spectroscopy operates by using a reference sample of the target gas as a spectral "fingerprint" to identify the presence of the same gas in a measurement cell. Here, we use Complementary Source Modulation (CoSM), where two broadband light sources are intensity modulated in anti-phase, and where the first source is coupled to the measurement sample after passing through the reference sample, whereas the second is directly-coupled. These two beams are combined in such proportions that there is no net intensity modulation, and the resulting light then passes through the measurement sample. The subsequent difference in attenuation, that light originating from each source suffers in the measurement region, results in an amplitude modulation of the beam after transmission through the measurement cell. The amplitude modulation index is indicative of the concentration of target gas present in this measurement cell.

We present analyses to show predictions of the magnitude of this modulation index and the anticipated signal to noise ratio in measurements, factors which indicate the expected minimum detectable gas concentration. Spectral absorption data of the gases is obtained from the publicly available HITRAN database. It is assumed that a junction photo-diode, as used in many fibre-based systems, is used to evaluate output light intensity. Effects of changing the pressure and temperature of gases in the reference and measurement cells have also been modelled.