ABSTRACT

Optical fibre sensors can be used to measure a wide variety of properties. In some cases they have replaced conventional electronic sensors due to their possibility of performing measurements in environments suffering from electromagnetic disturbance, or in harsh environments where electronics cannot survive. In other cases they have had less success mainly due to the higher cost involved in fibre-optic sensor systems.

Intensity modulated fibre-optic sensors normally require only low-cost monitoring systems principally based on light emitting diodes and photo diodes. The sensor principle itself is very simple when based on coupling between fibres, and coupling based intensity modulated sensors have found applications over a long time, mainly within position and vibration sensing.

In this thesis new concepts and applications for intensity modulated fibre-optic sensors based on coupling between fibres are presented. From a low-cost and standard component perspective alternative designs are proposed and analyzed in order to find improved performance. The development of a sensor for an industrial temperature sensing application, involving aspects on multiplexing and fibre network installation, is presented. Optical time domain reflectometry (OTDR) is suggested as an efficient technique for multiplexing several coupling based sensors, and sensor network installation with blown fibre in micro ducts is proposed as a flexible and cost-efficient alternative to traditional cabling.

A new sensor configuration using a fibre to a multicore fibre coupling and an image sensor readout system is proposed. With this system a high-performance sensor setup with a large measurement range can be realised without the need for precise fibre alignment often needed in coupling based sensors involving fibres with small cores. The system performance is analyzed theoretically with complete system simulations on different setups. An experimental setup is made based on standard fibre and image acquisition components, and differences from the theoretical performance are analyzed. It is shown that sub-µm accuracy should be possible to obtain, being the theoretical limit, and it is further suggested that the experimental performance is mainly related to two error sources: core position instability and differences between the real and the expected optical power distribution. Methods to minimize the experimental error are proposed and evaluated.