Streszczenie w języku angielskim rozprawy doktorskiej mgr inż. Jędrzeja Barańskiego pt. „Opracowanie laserowego modułu absolutnego i precyzyjnego pomiaru odległości z przeznaczeniem do maszyn obróbczych".

Computer-controlled machining centres are increasingly common in manufacturing plants. Machine tools, like any mechanical device, are subject to gradual wear and require periodic calibration to maintain machining quality. Laser interferometers are used for this purpose because of their measurement accuracy. Interferometers measure displacement rather than absolute distance, making them impractical for volumetric measurements and calibration of, for example, large machining centres or robotic manipulators. Absolute distance measurement systems are much better suited for such applications. As part of an implementation dissertation at Lasertex, which develops and manufactures systems for the calibration of machining centres, a complete design of a laser module for absolute and precise distance measurement for the calibration of machining machines was implemented.

The dissertation presents an overview of the various distance and displacement measurement methods, within which the various system realisations are discussed taking into account their achievable accuracy and measurement range. Characteristic problems, measurement errors and ways to minimise these are presented for each method. Due to the implementation nature of the PhD, a review of commercial distance and displacement measurement systems was also carried out, identifying their key parameters and the price of the devices.

The thesis presents an iterative implementation of a rangefinder module, where five prototypes of the device were designed, launched and characterised. For each design, the specification of the optoelectronic circuits was discussed and key issues were identified, which were corrected in subsequent versions. The latest device synthesises a modulation frequency signal in the range of 4 GHz to 10 GHz and uses a 1550 nm telecommunication laser with an electroabsorption modulator. The rangefinder realises a proprietary high-frequency transmit and receive path using a radio hybrid laminate, as well as a laser temperature stabilisation system and a fibre-optic system with a parabolic mirror as a collimator to add the laser beam in visible light. The instrument operates fully autonomously, has a screen displaying results and runs on accumulators. The implemented software allows the measurement to be carried out automatically in absolute or continuous mode. The work also included the realisation of an application to display the results from the rangefinder for diagnostic purposes.

The dissertation discusses the physical principles of the effect of amplitude modulation of optical signals on the phase modulation of electrical signals in PIN-type photodiodes and the resulting phase noise. Two original experimental setups were developed to characterise silicon and indium gallium arsenide (InGaAs) photodiodes and, with their help, the photodiodes were characterised and optimal operating points for which the phase noise is lowest were identified. The impact of this effect in distance measurement applications was also presented and it was shown that by optimising the photodiode operating point, the phase noise can be improved several times and the susceptibility to distance measurement error by varying the illumination intensity can be reduced.

As a summary of the work performed, the distance measurement accuracy of the prototype rangefinder using the coordinate measuring machine was verified, as well as the repeatability and long-term stability. The distance measurement accuracy of the rangefinder was determined to be 23 µm + 1 µm/m. The standard deviation of the measurement repeatability is 2.9 µm and the maximum measurement range is 33 metres.

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