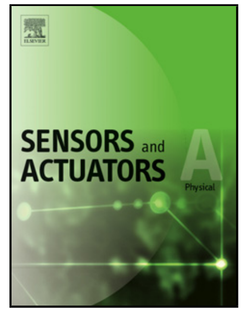
Accepted Manuscript



Title: Waterproof Sensor System for Simultaneous Pressure and Hot-Film Flow Measurements

Author: Martin Schwerter Monika Leester-Schädel Andreas Dietzel

PII: S0924-4247(16)30775-0
DOI: http://dx.doi.org/doi:10.1016/j.sna.2017.02.010
Reference: SNA 9993

To appear in: *Sensors and Actuators A*

Received date: 26-10-2016
Revised date: 24-1-2017
Accepted date: 10-2-2017

Please cite this article as: M. Schwerter, M. Leester-Schädel, A. Dietzel, Waterproof Sensor System for Simultaneous Pressure and Hot-Film Flow Measurements, *Sensors and Actuators: A Physical* (2017), http://dx.doi.org/10.1016/j.sna.2017.02.010

Waterproof Sensor System for Simultaneous Pressure and Hot-Film Flow Measurements

Martin Schwerter[1], Monika-Leester-Schädel, Andreas Dietzel

Institute of Microtechnology TU Braunschweig, Alte Salzdahlumer Str. 203, 38124 Braunschweig, Germany

ABSTRACT

For simultaneous measurement of pressure and near surface flow conditions allowing indirect determination of wall shear stress in experimental water tunnel environment an integrated hybrid sensor system has been developed. In contrast to known approaches, which are limited to the use in gas atmosphere due to protruding electrical and fragile parts, our sensor system is waterproof shielded and embedded in epoxy resin. Furthermore an amplification circuit for the pressure signal based on a programmable gain amplifier is integrated in direct vicinity to the pressure sensor in order to minimize noise by electromagnetic disturbances. Also sensor systems with on-board digitalization of the pressure signal for direct digital read-out were realized. We present all aspects of system assembly and embedding to one waterproof module. Furthermore, read-out strategies as well as sensor test results in air and water are shown and watertightness is confirmed.

Keywords: pressure sensor; hot-film sensor; embedded sensor system; waterproof; integrated electronics; FPGA signal processing

1. INTRODUCTION

The importance of air traffic increases in a more and more globalized word. The International Air Transport Association (IATA) predicts an average annual growth for the number of passengers of 3.8% up to 2034 [1]. In order to reduce the impact of the increasing flight traffic on residents in airport-near urban areas different technologies for noise and pollution reduction are developed [2]. Among these an active high-lift system with a highly curved Coanda flap including feedback from flow and pressure sensing is investigated, which shall help reducing airport approach speeds and noise, thereby improving aircraft compatibility to smaller airports with shorter take-off and landing fields [3]. The active high-lift system is investigated within water tunnel experiments in which information about flow condition shall be obtained by pressure and hot-film sensors and serves as input for the closed loop control. By using water instead of air (classic wind tunnel) both the control frequency and the free-stream velocity are reduced by a factor of around 10. But sealing and electrical isolation of flush-mounted sensors are challenging. Further the airfoil model is scaled down to a chord length of 300 mm and is made of stainless steel in order to withstand the stress in the water tunnel [4]. These geometric restrictions only allow a shallow notch with a cross section of 10 mm · 2.5 mm for wall shear stress and pressure sensor placement in the model. Best information about the flow is obtained by hot-film and pressure sensors being placed in close proximity. Electromagnetic disturbances of the weak signals from the pressure sensor can be avoided by early amplification and optional digitalization. As a consequence a very compact and waterproof sensor system combining both types of sensor together with integrated signal conversion is required.

2. STATE OF THE ART

A huge range of fluidic pressure and direct or indirect shear stress sensors have been developed. Pressure sensors are available based on different sensor principles (i.e. piezoelectric, piezoresistive, capacitive), applicable to various pressure ranges and with different geometric dimensions. A wall shear stress measurement may be realized using a floating element, a fence or heated wire transducing principles [5] [6] [7]. The measurement of pressure and wall shear stress in one miniaturized device is possible but research activities on such combinations are quite limited. Kälvesten et al. [8] designed a sensor system for turbulent measurements in gas flows on a silicon-on-insulator (SOI) substrate. The piezoresistive pressure sensor contains a polysilicon membrane and polysilicon piezoresistors, the shear stress

[1] corresponding author: m.schwerter@tu-bs.de