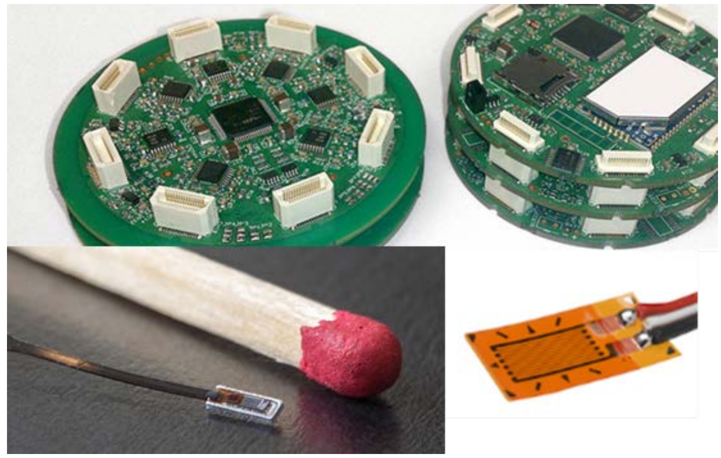
Wireless multi-sensor measurement system:

- On-board electronics with embedded ADC and Wi-Fi
- 16 simultaneous channels
- 200kHz sampling rate
- Gain range: 1 to 128
- Data monitoring sofware



The wireless multi-sensor measurement system consists of a fast high resolution analog-to-digital recorder and logger. They are designed to be operated in the rotating frame of reference up steady accelerations of 25’000 g.

Each boards has 4 analogue input channels synchronized from a single optical signal, and the boards can be stacked up to 4 boards offering 16 simultaneous analogue voltage acquisition channels . The boards are specifically design to acquire dynamic signals up to a sampling frequency of 200kHz per second. The data are temporarily stored on an on-board mini solid state disk, before being sent to an external computer through an embedded Wi-Fi module.

Each boards can acquire either 2 piezo-resistive pressure sensors or 4 strain gages operated in a constant current mode. The board can be configured for the usage of LSc’s SMA and CMA fast-pressure sensors assemblies, which has the advantage of offering fully calibrated measurement chain for high accuracy type of measurements. The boards can also be used to measure with resistance thermometers such as Pt100.

General Specifications:

- **Sampling rate: 200kHz**
- **16 bit resolution ADC**
- **Voltage acquisition range: 0 – 5V**
- **4-boards in stack configuration with 16 simultaneous differential analogue input channels**
- **Gain range: 1 to 128**
- **Compatible with: piezo-resistive pressure sensors, strain gages or Pt100**
- **On-Board data storage with wireless data transmission**
- **Optical trigger for phase-locking**
- **dimensions: 64.9 or 74.9mm diameter, 9mm height**

Options:

These boards can be ordered with LSc’s blade mount and casing mount fast –pressure sensors (see: SMA or CMA product sheets). The sensors will be delivered calibrated with the on-board electronics, and a set of polynomial calibration coefficient will be provided to be used with LSc’s monitoring software.

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An On-Board Wireless Multi-Sensor Measurement System for Rotating Turbomachinery Application

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ABSTRACT

A novel multi-sensor wireless measurement system for measurements in the rotating frame of reference is presented and demonstrated in this paper. The system is comprised of newly developed in-house surface mount pressure sensors and wireless signal conditioning and acquisition boards. The surface mount pressure sensor assemblies are packaged a miniature aluminum casing of 1.75mm x 0.81 x 0.47mm. The RTV-coated assembly offers the highest measurement bandwidth of 210 kHz which provides a measurement bandwidth at least 40 times above the maximum intended blade passing period. The uncertainty analysis performed shows that the pressure sensors offer a measurement accuracy of ±87Pa and ±77Pa in absolute and fluctuating pressure measurements, respectively. The sensors and the wireless data acquisition boards provide a high signal-to-noise ratio with a pressure resolution of 6Pa on the raw signal. The measurement system is successfully deployed in an axial one-and-1/2-stage-turbine facility, and preliminary measurements are presented and discussed.

NOMENCLATURE

A	area	[m^2]
L	length	[m]
P,p	pressure	[Pa]
S	sensitivity	[mV/mbar]
T	temperature	[^{o}C]
U	pressure signal	[V]
U_e	Temperature signal	[V]
f	frequency	[Hz]
k	stiffness	[Nm/rad]
m	mass	[kg]

Greek

σ	standard deviation

Abbreviations

FRAP	fast-response aerodynamic probe
TCO	temperature coefficient of offset
TCS	Temperature coefficient of span
SMA-RTV	surface mount pressure sensor assemblies coated with RTV
SMA-PS	surface mount pressure sensor assemblies with perforated screen

Subscripts

abs	absolute
e	excitation
fluct	fluctuating
avg	average value
min	minimum
max	maximum
rel	relative

INTRODUCTION

In turbomachinery, blades suffer from flutter or forced response depending on the type of application and operating conditions. In the early stage of new turbine or compressor development, the design focuses on satisfying the mechanical integrity of the rotating parts to meet the requirements in terms of expected effective operating hours. For now many years the design of new aero-engines is focusing in minimizing the weight. This is achieved by reducing the number of stages and therefore increasing the blades loading. As reported in [1-3], it is vitally important to study the sources of inter-blade row interactions on the aerodynamic blade excitation to mitigate the risk of early failure. Similarly, centrifugal compressors have gone through considerable developments over the past 10 years, evolving towards high speed, high efficiency and high pressure ratio compressors. The current design trends tend to increase the risks of failure. Several research groups have worked in identifying the sources of excitations related to wake potential field interaction with the impeller as well as with the primary and secondary flow paths [4-6].

This process relies on the capability to predict the cause and magnitude of blade excitation and to assess damping mechanisms. To enable this kind of quantification, the measurement of the unsteady pressure acting of the blades has to be coupled to the blade mechanical deformation over the entire range of intended operating conditions. It requires conducting measurement in the rotating frame of reference, which is more challenging to construct and instrument at the same degree than stationary experiments. This becomes especially true if the blades have to be equipped with a high