UNIVERSITY OF PAVIA

ENGINEERING FACULTY

PhD School of Doctorate in Bioengineering and Bioinformatics

Design and Development of a Novel Capacitive Sensor Matrix for Measuring Pressure Distribution

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Summary

1. Introduction to the problem of discomfort during the drive
2. Evaluation of discomfort
3. Realization of the prototype matrix
4. The electronic circuit
5. The microprocessor
6. Experimental results
7. Conclusions and future developments

Fatigue during the drive

Prolonged attention → ***FATIGUE***

- 20% of car accidents are due to driver's fatigue
- 40% of mortal accidents in the USA are caused by drivers falling asleep

*More than **10-15 min** of seated posture*

↓

Compromised blood flow in the involved regions

↓ ↓

Increase of fatigue *Slowdown of reflexes*

Comfort vs discomfort

COMFORT: *completes the sense of wellbeing with the concepts of health and safety*

DISCOMFORT: *connected to biomechanical factors, involving muscular and scheletric apparatuses*

EVALUATION OF DISCOMFORT TO PREVENT PAIN IN AUTOMOTIVE ENVIRONMENTS

Discomfort evaluation

STATIC APPROACH

Posture of the spinal cord

Pressure distribution on the seat surface

DRAWBACKS:

- laboratory experiments
- reduced periods of time

QUESTIONNAIRES

DRAWBACKS:

- subject's ability to describe the discomfort
- environmental variables interpreted by the sensory system
- only the perceived discomfort can be evaluated

Discomfort during the drive

OBJECTIVE MEASURE of DISCOMFORT

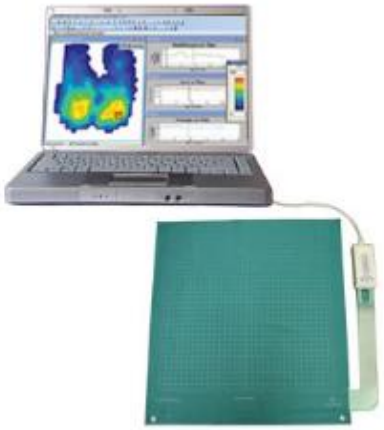
ELECTRONIC INSTRUMENTATION

SENSORISED MATTRESSES

- capacitive or resistive sensors
- centre of pressure study
- seat implementation

Commercial devices

- systems not adaptable to specific situations
- difficult economic application



Design of a capacitive sensor matrix to detect applied pressure

Good time response and precision

Low cost and appropriate seat's dimensions

Centre of Pressure (CoP)

Centre of Pressure: ***point of application of the resultant of the vertical forces that act upon the support surface***

useful to observe the phenomenon of ***"fidgeting"***

$$COP(X,Y) = \left(\frac{\sum(\text{pressure} \times \text{x-coordinate})}{\sum \text{pressure}}, \frac{\sum(\text{pressure} \times \text{y-coordinate})}{\sum \text{pressure}} \right)$$

Critical points of the prototype

a. dimensions of the capacitors
b. distance between adjacent sensors
c. dielectric placed between the capacitors' armors

- *material of the armors: thin film of copper*
- *facet of the square sensor = 1,5 cm*
- *distance between sensors = 3 cm*
- *dielectric material: silicone*

Critical points of the prototype

SILICONE

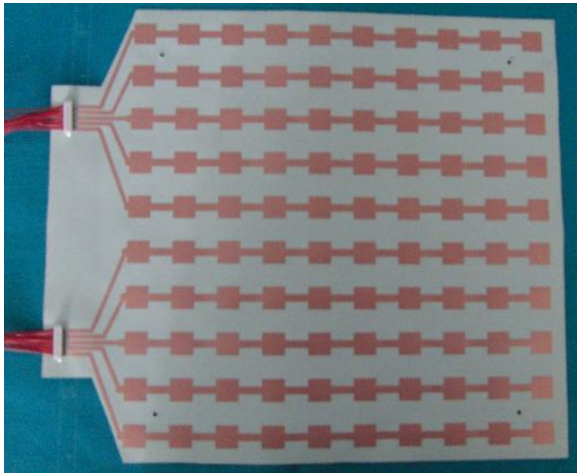
flexibility for the seat adaptation

elasticity to deform without cracking

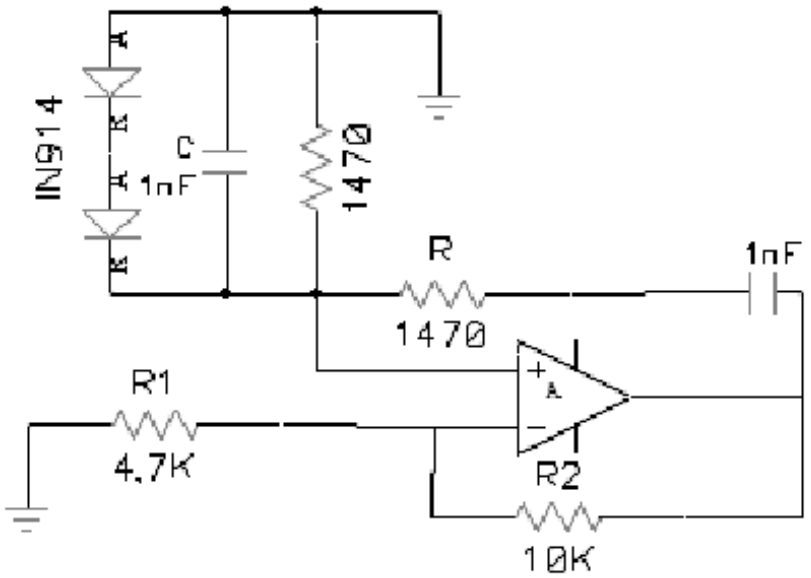
local deformations without cross-talk in adjacent sensors

Matrix parameters :

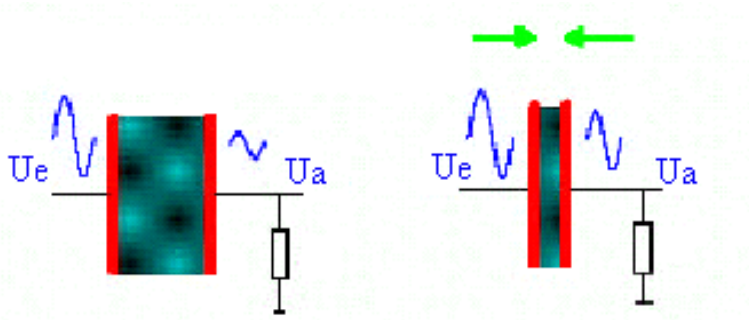
- *square matrix with facet = 30 cm*
- *10 rows x 10 columns → 100 sensors*



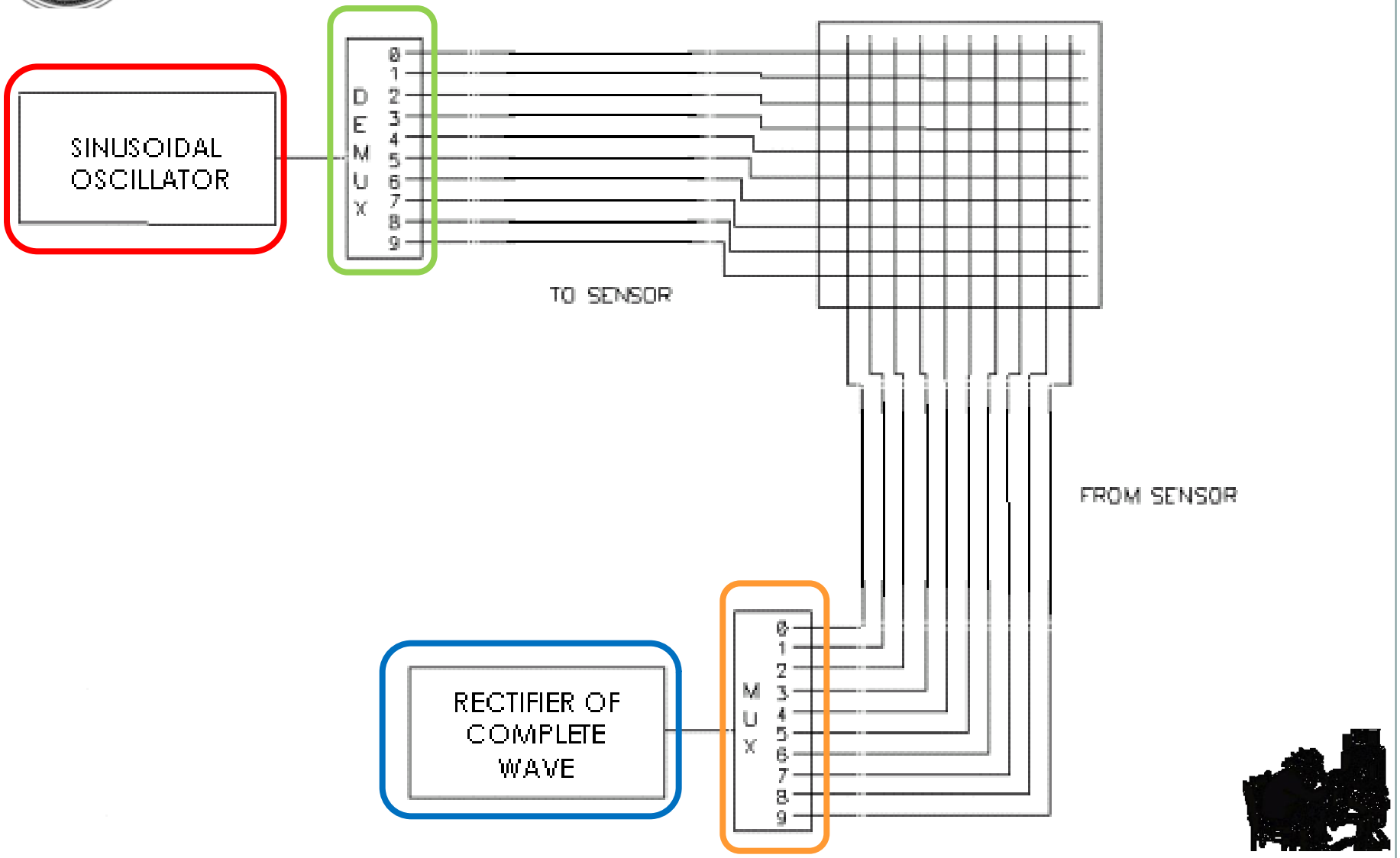
Wien bridge oscillator



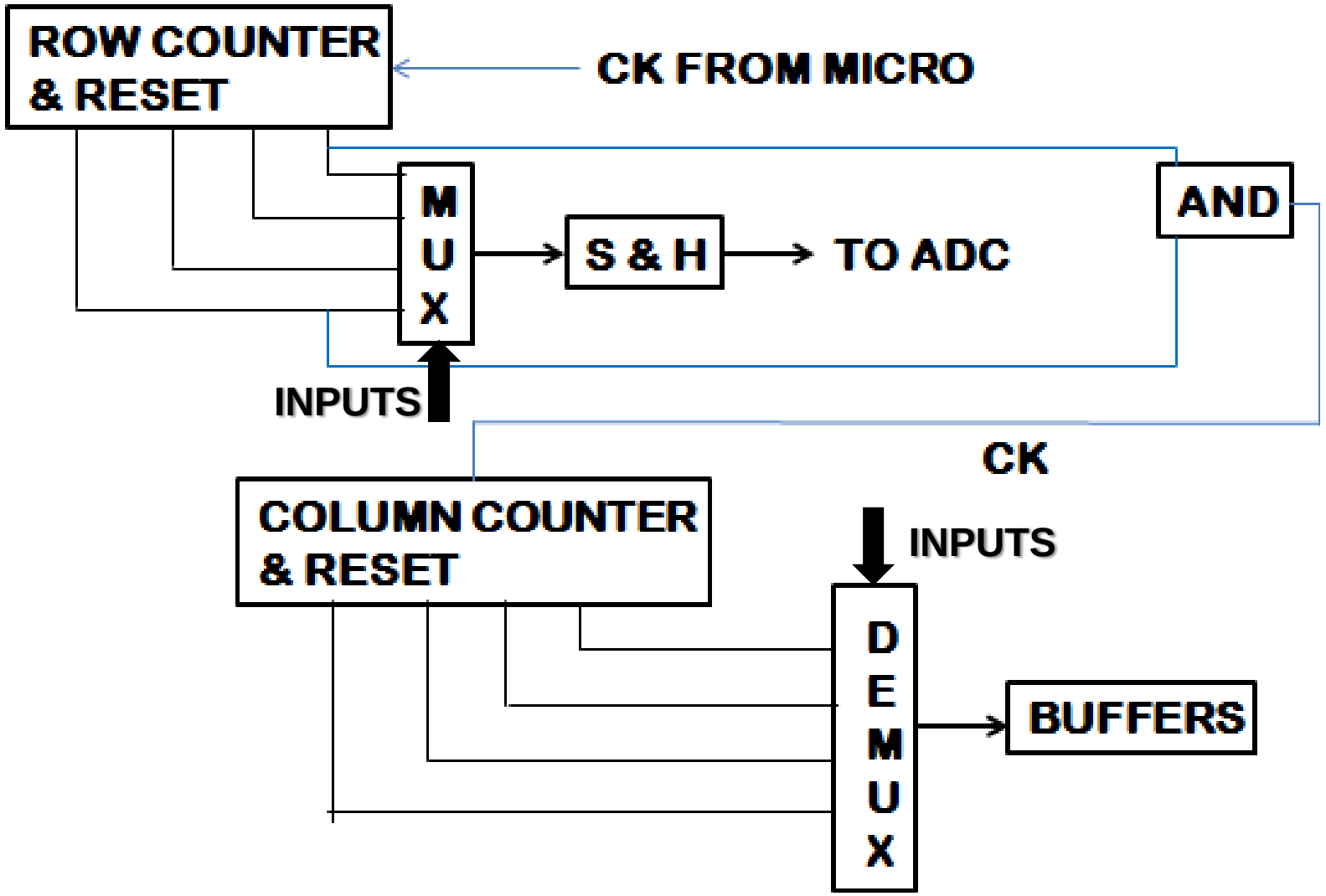
- ✓ **frequency of the oscillator: 100 kHz**
- ✓ **gain of the operational amplifier: A = 1 + R2/R1 = 3**



Electronic circuitry



Sensors' piloting circuitry



The Digital Signal Processor

DSP TMS320LF2407A by Texas Instruments:

1.Scanning of the matrix on rows and columns

2.Sampling of the sensor's signal together with the representation of the correspondent pressure value

3.Calculation of CoP coordinates

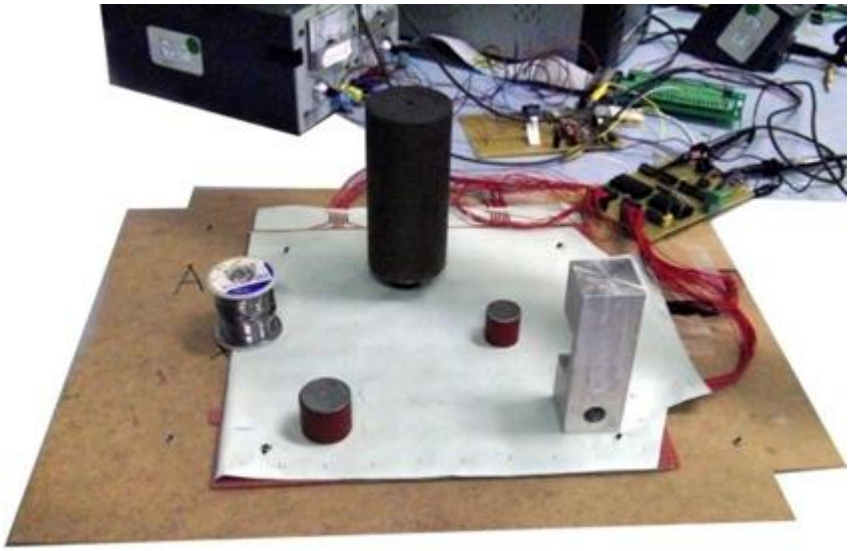
4.Transmission to a personal computer, through Bluetooth module for debug purposes:

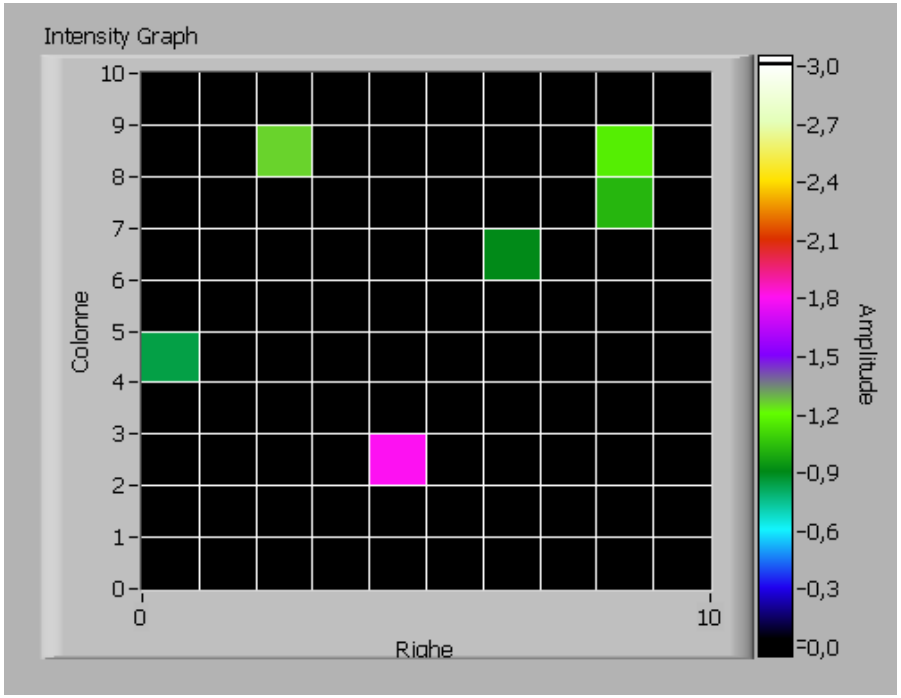
- Converted signals coming from the capacitors
- Sensor's coordinates
- CoP coordinates

ADVANTAGES:

- *High speed of calculation*
- *Large amount of memory space to allocate data*
- *Optimization of the performance through the use of assembly language*

Tests of the prototype





Conclusions and future developments

SENSOR MATRIX

ELECTRONIC CIRCUIT

MICROPROCESSOR

SOFTWARE LABVIEW

POSSIBLE IMPROVEMENTS:

- Optimization of the electronic circuit
- Better S/N ratio
- Use of a faster Bluetooth module

CONCLUSIONS:

- ✓ Adaptation ability to automotive environments
- ✓ General purpose device for different kinds of applications

FUTURE DEVELOPMENTS:

- *Design of an actuation system for a seating adaptation strategy in order to improve the level of comfort*

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Thank you for the attention!