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PREFACE

The Military Technical Institute, the first and the largest military scientific-research institution in Serbia with a 68 year long tradition, has been traditionally organizing the OTEH scientific conference devoted to the defensive technologies. The Conference is sponsored by the Ministry of Defense and it takes place every second year.

Its aim is to gather scientists and engineers, researchers and designers, manufactures and university professors in order to exchange ideas and to develop new relationships.

The Seventh International Scientific Conference OTEH 2016 is scheduled as follows: lecture on the occasion of Mileva Marić - Einstein, plenary session with two introductory lectures, working sessions according to the Conference topics, exhibition of some actual exhibits of the weapons and military equipment developed by the Military Technical Institute.

The papers which will be presented at the Conference have been classified into the following thematic fields:

- Aerodynamics and Flight Dynamics
- Aircraft
- Weapon Systems and Combat Vehicles
- Ammunition and Energetic Materials
- Integrated Sensor Systems and Robotic Systems
- Telecommunication and Information Systems
- Materials and Technologies and CBRN Protection
- Quality, Standardization, Metrology, Maintenance and Exploitation.

The Proceedings contain 134 reviewed papers which have been submitted by the authors from 15 different countries. I would also like to stress that 24 papers are from abroad. The quality of papers accepted for publication achieved very high standard. I expect stimulated discussion on many topics that will be presented during two days of the Conference.

On behalf of the organizer I would like to thank all the authors and participants from abroad, as well as from Serbia, for their contributions and efforts which made this Conference possible and successful.

I would also like to thank the Ministry of Education and Science of the Republic of Serbia for its financial support.
Finally, dear guests and participants of the Conference, I would like to wish you an enjoyable stay in Belgrade and I am looking forward to see you again at the Eighth Conference.

Belgrade, October, 2016

Miodrag Lisov
Chairman of the Scientific Committee

C O N T E N T S

OCCASIONAL LECTURE

PLENARY LECTURES

1. SECTION : AERODYNAMICS AND FLIGHT DYNAMICS

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4. SECTION : AMMUNITION AND ENERGETIC MATERIALS

5. SECTION : INTEGRATED SENSOR SYSTEMS AND ROBOTIC SYSTEMS

7. SECTION : MATERIALS, TECHNOLOGIES AND CBRN PROTECTION

8. SECTION : QUALITY, STANDARDIZATION, METROLOGY, MAINTENANCE AND EXPLOITATION

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CHANNEL SELECTOR FOR OPTIMIZATION OF TEST AND CALLIBRATION PROCEDURES OF ICTM PRESSURE SENSORS

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Abstract: *This paper presents channel selector developed for improvement of the efficiency of the test and callibration procedure of ICTM pressure sensors. So far, this procedure allowed testing of only one sensor at the time. The channel selector enables simultaneous testing of up to five pressure sensors. This implies many benefits, such as: reduction of power consumption, reduction of the amount of gas used in the measurement system, significant saving of time needed for testing of a small series of pressure transmitters. Realization of the channel selector is based on use of a reed relay which is driven by specially designed electronics. There are two modes of operation of this device. The first one is by manual channel selection, while the second one is based on PC control realized by using dedicated software and microcontroller which are incorporated in the device itself and connected via USB communication. During the test and callibration procedure pressure is generated by MENSOR APC-600 pressure calibrator, while temperature is controlled using temperature test chamber HERAEUS VÖTSCH VMT 08/140.*

Keywords: *pressure sensor, callibration, channel selector, reed relay, USB communication.*

1. INTRODUCTION

One of the main research and development areas at the Centre of Microelectronic Technologies, which belongs to the Institute of Chemistry, Technology and Metallurgy (ICTM) is the field of pressure sensors. More than 25 years ago, ICTM pressure sensors [1] have reached the commercial level. The latest generation of ICTM pressure sensors is SP-12 which demonstrated exceptional sensor linearity to the burst pressure [2]. These commercial devices require reliable and efficient test and callibration procedures. In the last years, much efforts have been put on improvement of these procedures [3, 4]. This paper presents new procedure based on channel selector. Such solution contributes significantly to the improvement of the efficiency of the test and callibration procedure of ICTM pressure sensors.

Currently, there are two types of commercial channel selectors available on the market: the first ones developed by renomated companies like National Instruments, which are very expensive and offer numerous options [5], while the second ones are produced by small companies with questonable quality, reliability and warranty [6].

While the first type of selectors would fulfill our technical requirements, the main drawback is the price and the existence of too many unnecessary options.

The main drawbacks of the second type of commercial selectors are:

– Limited number of channels,
– Software limitations,
– Lack of flexibility,
– Questonable quality, reliability and warranty,
– Problems with delivery.

Motivated by all these facts, we developed a flexible channel selector that suites our needs, which can operate fully automatically controlled by PC, or manually controlled by operator. In our case, the channel selector performs selection of the pressure sensors.

The first drawback to be eliminated was the limited number of channels. In the current measurement set-up optimal number of channels is five. On the other hand, we needed simultaneous connection of the four lines from each sensor: two are connecting sensors's input with multimeter and the second pair is connecting sensor's output with the another multimeter. Further, we needed options for programmable or manual switch for sensor selection.

2. TECHNICAL REQUIREMENTS

The first stage in development of sensor selector was the definition of the technical requirements. The device should enable sequential measurements of several sensors under the same conditions. The same measurement

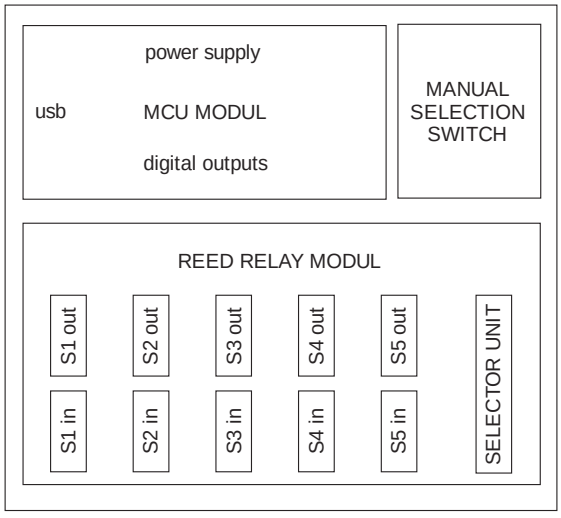
conditions comprise placement of the sensors in the same test chamber at the same pressure line. Test chamber should provide controlled temperature, while the pressure line is connected with the Mensor APC 600 pressure callibrator which provides pre-defined pressure values at which sensors are tested.

These sequential measurements should have two options: 1) selector is contolled by an external PC or 2) selector is controlled by an operator who can, independently of the external software, choose the sensor to be tested. Another very important aspect taken into account during the device design was compatibility with the already existing connectors in the lab. Measurement setup established earlier in our lab for test and callibration procedure of single sensor used certain types of connectors and compatible solution is used when designing the selector.

Taking into account all previously mentioned requirements we have designed and fabricated the device. We have considered possibility of incorporating digital switches consisting of electrical circuits or reed relays. After thoroughly analysing both options, we decided to use reed relays. Ten integrated circuits, each containing 2 reed relays, are needed for our configuration. Choice of integrated circuit is performed by digital outputs of the microcontroller connected via ULN2003 integrated circuit consisting of transistors in Darlington pair configuration.

3. DESCRIPTION

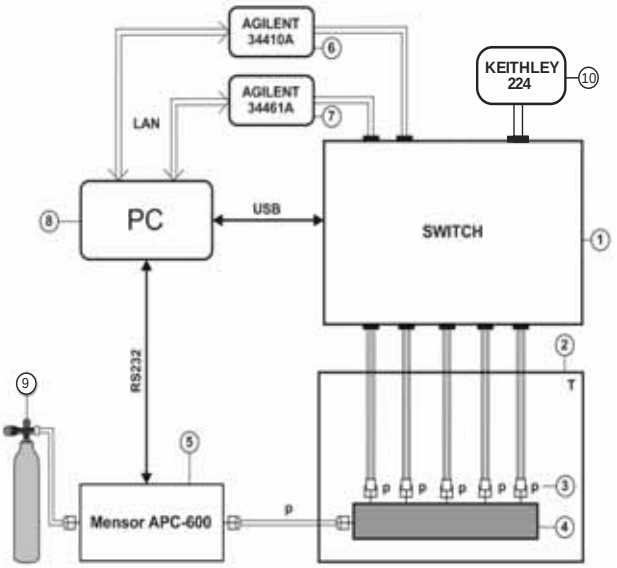
Block diagram of the channel selector MPX-1 is presented in Picture 1. The main elements of MPX-1 device are shown. The selector consists of two digital modules and an independent switch for manual selection.



Picture 1. Channel selector MPX-1

Digital module incorporated in the microcontroller enables PC connection providing at the same time automatization of the process of test and callibration of the sensors as illustrated in Picture 2. The selector device can operate either in manual mode where the operator is choosing the sensor to be tested or in automatic mode where specialized software installed on PC which controls the measurement system is performing the tasк of choosing the sensor.

Two programmes are required for such functioning of the device. The first one is written for the microcontroller and it enables independence of the device and combination of the channels overlapping as desired. The second programme is the user interface installed on PC. This programme can be installed as independent software which enables overlapping according to the needs or it can run as a subroutine within the more complex programme which runs the system containing MPX-1.



Picture 2. System for test and callibration of the sensors where the channel selector MPX-1 is implemented as a sensor selector: 1 - Sensor (channel) selector MPX-1; 2 – Temperature test chamber HERAEUS VÖTSCH VMT 08/140. Measurement temperature is set and maintained. Temperature value is obtained from the temperature sensor placed inside the chamber; 3 - Pressure sensor; 4 - pneumatic manifold with 5 connectors, in each connector a sensor to be tested is connected; 5 - Pressure calibrator Mensor APC600; 6 - Multimeter Agilent 34410a measures voltage value, U_d, at the input of the sensor; 7 - Multimeter Agilent 34461a measures voltage value, U, at the output of the sensor; 8 - PC with the installed software which controlls and runs the; 9 - Gas container under pressure; 10 – Current source Keithley 224

System for test and callibration of the sensors based on the channel selector MPX-1 is presented in Picture 2. Brief description of each part of the system is also given.

Picture 3. Front panel of the sensor selector MPX-1

Connectors are placed both on the front and rear panels of MPX-1 selector. Connectors on the front panel enable connection of the collector, therefore of the sensor also, with the measurement instruments as shown in Picture 3.

The connectors placed on the front panel are labeled as following:

+IN and –IN serve for connection with the constant current source (2.5mA)

+D and –D for connection with the digital multimeter which reads voltage value at the input of the sensor, Ud

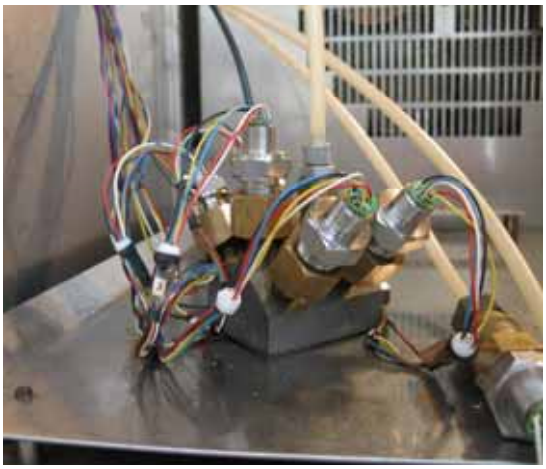
+OUT and –OUT are connected with the digital multimeter which reads the voltage value at the output of the sensor, U

On the rear panel, connectors of Binder 680 type enable connection of the device with the tested sensors as shown in Picture 4. Besides that, an additional Binder 680 connector is placed on the rear panel, which serves for connection with the acquisition device IHTM SMART.

On the rear panel, there is also a connector for additional 5 V supply, which is needed when an operater controls the measurements. On the other hand, this additional voltage supply is not needed if the device is run by PC. In that case, voltage is provided by USB port.

Picture 4. Rear panel of the sensor selector MPX-1.

Picture 5 shows photograph of the measurement configuration with five pressure sensors. The sensors are placed inside the test chamber at fixed temperature and all of them are connected to the same pressure line.



Picture 5. Photograph of five pressure sensors placed inside the test chamber during the measurements.

Table 1 gives an example of the measurement results obtained for one pressure sensor tested at 11 measurement points (11 pressure values) for the fixed temperature of 20,8°C inside the test chamber.

Table 1. Measurement results obtained for the pressure sensor SP-12 30μm during one measurement sequence..

Measurement No. 1	T[°C]	20,8
	U_d[mV]	6192
p_a[bar]	U[mV] ↑	U[mV] ↓
1,1	41,38	41,385
2,1	70,14	70,14
3,1	98,84	98,84
4,1	127,47	127,475
5,1	156,02	156,025
6,1	184,49	184,49
7,1	212,86	212,86
8,1	241,13	241,13
9,1	269,28	269,28
10,1	297,31	297,31
11,1	325,21	325,21

4. CONCLUSION

The channel selector MPX-1 presented in this paper was developed in order to overcome numerous drawbacks existing in the earlier procedure for test and callibration of ICTM pressure sensors. Previously used procedure allowed measurement of only one sensor at a time, requiring repeated connection and disconnection of the electrical wire connectors during the exchange of the tested sensors. This results in damagining the connectors and possible breakage of the the wire connectors.

The channel selector MPX-1 enables simultaneous testing of up to five pressure sensors, therefore it acts as a sensor selector. MPX-1 provides connection of each tested sensor individually with the instruments which serve for voltage supply and for the measurement of the sensor's output voltage. Implementation of the sensor selector MPX-1 eliminates problems described above because the connection is realized through microswitching components instead of attaching-detaching of the external connector elements.

Implementation of the sensor selector implies many benefits, such as: reduction of power consumption, reduction of the amount of gas used in the measurement system and significant saving of time needed for testing of a small series of pressure transmitters.

ACKNOWLEDGMENT

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References

[1] Djurić,Z., Matović,J., Matić,M., Mišović,S.N., Petrović,R., Smiljanić,M., Lazić,Ž.: Pressure Sensor with Silicon Diaphragm, Proc. XIV Yugoslav Conference on Microelectronics MIEL, Belgrade (1986) 88–100.

[2] Matić,M., Lazić,Ž., Radulović,K., Smiljanić,M.M., Rašljić,M.: *Eksperimentalno određivanje optimalne linearnosti senzora pritiska*, Proc. 57th Conference for Electronics, Telecommunications, Computers, Automation and Nuclear Engineering ETRAN, Zlatibor, vol. MO3.1. (2013) (in Serbian)

[3] Vorkapić,M., Starčević,M., Popović,B., Frantlović,M., Poljak,P., Minić,S.: Model *za unapredjenje ispitivanja transdjusera u maloserijskoj proizvodnji*, Tehnika – Kvalitet, standardizacija i metrologija, 11(6) (2011) 1043-1047. (in Serbian)

[4] Poljak,P., Vukelić,B., Vorkapić,M., Randjelović,D.V.: *Prototype of the Multichannel Acquisition System Developed for ICTM Pressure Transmitters*, Electronics, 19(2) (2015) 66-69.

[5] PCI General Purpose Relay Cards http://www.pickeringtest.com/en-rs/products/pci/switch-cards /general-purpose-relay

[6] JSB2434 USB DPST four (4) Reed Relays Module http://www.j-works.com/jsb2434.php