Elements of Shielding in Sensors Connecting

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Abstract— **This paper tries to address noise immunity in order to obtain high precision measurements in industry and beyond. Currently, existing technologies allow to achieve high precision measurement and data acquisiton systems, instruments at which the noise threshold down well below thresholds perturbation levels generated by the explosion of devices and instruments that emit electromagnetic radiation in the environment. Removal of these parasites that overlap with good signal and tend to drown in noise the low level signals bearing information can be made connecting and proper shielding both ways of communication and transmission and devices from the considered chain. Depending on the type of signals, there is a second level, that corresponding filters for analogic signals or software for digital information.**

Index Terms—**connecting, sensor, shelding, precision,**

I. INTRODUCTION

An electrical device is considered appropriate in terms of electromagnetic compatibility if as a transmitter produces tolerable emissions and as a receiver has an acceptable sensitivity to perturbations, i.e. has a sufficient immunity to perturbations.

On the most electronic equipment we can today read: *„This devices Complies with part 15 of the FCC Rules. Operation is subject of the following two conditions: (1) This devices may not cause harmful interference; (2) This device must accept any interference received, including interference that may cause undesired operation. WARNING: This apparatus must be earthed”*.

If such provisions relate to electrical and electronic household appliances or office devices, especially in industrial environments (more disturbed and exposed to disasters), the disturbances shielding problem becomes more important.

The concept of *Electromagnetic Compatibility* has its origins in influence or interface process known in radio technique, meaning that if a radio receiver, given the frequency of a radio transmitter, receives another transmitter also, we attend an interference phenomenon.

In time, with the multiplication of electrical appliances and devices, along with conventional radio transmitters, it was necessary to reconsider the content of the concepts of „transmitter” and „receiver”. The concepts of „transmitter” and „receiver” is no longer used today only at the communication methods, and have a broader acceptance.

In this regard, it is considered as transmitters of electromagnetic energy both the television and radio transmitters and the electrical circuits and systems that unintentionally produce electromagnetic energy and pollute the environment, such as:

- radio broadcasting systems, television, radar;
- gas discharge lamps during the ignition phase;
- electric motor with commutator;
- rectifiers and inverters;
- gas discharge tubes;
- nuclear explosions.

Examples of electromagnetic energy receivers:

- information receiving systems (telephone, radar, radio and TV receivers, etc.).
- semiconductor automation systems that can receive false signals;
- electronic measuring systems for electrical and non-electrical quantities (sensors, transducers, oscilloscopes, recorders, digital voltmeters);
- computer systems, computer networks;
- technological equipment operating with electron beam;
- electronic microscope;
- systems for data acquisition and processing;
- scanning systems of medical equipment;
- microelectronics from the vehicle;
- pacemakers.

Some electrical and electronic equipments may be considered in terms of EMC both transmitters and receivers.

An electrical or electronic device is considered compatible if as a transmitter produces tolerable emissions, and as a receiver has an acceptable susceptibility to harmful emissions (i.e. has a sufficient resistance to disturbance - or immunity). Electromagnetic compatibility problem arises first at receivers, when the flawless reception of an useful signal is affected. One speaks then about the existence of an *Electro-Magnetic Interference* (EMI). Sometimes just the perturbation quantity is named electromagnetic interference, although for this, at least at the receivers, the term *imision* is used. For example, a data acquisition and procesing system consisting of:

- sensors (current reducers, thermocouples, etc.) considered as source;
- connection line;
- data storage systems;
- interfaces;
- execution element, considered as receiver, can be influenced by harmful electromagnetic energy in any of its components.

Electromagnetic interferences may manifest as *reversible* or *irreversible* disturbances. Examples of *reversible disturbances* we have at the temporary lossing of intelligibility in telephone calls, clicks that appear at switching of household electric appliances (e.g., the appearance, at connecting of a refrigerator, of the sound and bright signal disurbance for televisions placed in the immediate vicinity), s.o. Examples of *irreversible disturbances* are the destructions of some electronic components on printed wirings due to the electrostatical charge, the overvoltages caused by lightning (which may lead to the destruction of electronic tubes for televisions or of some components for computers or computer networks), s.o.

II. INTERFACE ELEMENTS OF SENSORS IN PRECISION INSTRUMENTATION

The instruments are commercially available as standard modules, as modules for multiple signals, and as groups of non-powered power amplifiers. The individual modules are normally used in shelving modules with multiple channels that are equipped with a set of connectors on the back. These shelving modules can be ventilated or cooled through convection by vertical flows of air. The systems for multiple signals are often parts of a larger system in which the front panel controls for each channel are reduced in number or controlled by a computer. The groups of power amplifiers are integrated into other devices.

The measuring elements are most often attached to metal structures. These structures are usually connected to earth as a safety. If the structure is operational, you can often find electrical gradients across the structure due to their different discharge current. These currents come from motors, relays, safety wire, or radio-frequency external fields. The higher the test system may even be greater differences in ground potential.

The common sources may create problems of reliability. If power is affected by a short circuit of an indicator, all signals could be affected. If the source is classical, connection to ground of an indicator may not be detected only as a possible modification of the noise in the system. The indicator which made short circuit to the ground is obviously suspect, but if the system not shows signs of failure, the problem may go undetected. If two indicators make short circuit to the ground, then both indicators are removed from service or supply is affected. This issue of reliability is the main reason that the most users specify separated power supplies, isolated for each indicator device.

When devices with strain gauges bridge are powered separately, the resistors supplementing the bridge, located in a conditioning module or in an amplifier will be excited by a voltage higher than the voltage required, but this does not create a signal error.

The constant current sources can be used to avoid the errors given by the feeders. When the power source is constant, the voltage developed across the entire bridge is independent of cable length. When the bridge compensation resistors are located in a conditioning module or in an amplifier instrument, this part of the supply determines the impedance of the power supply. Note that an ideal current source has infinite impedance. However, if the compensation resistors are located near the active arms, the advantages of using a constant current source are lost.

Supplying with constant current source improves the linearity of output signal for many configurations of the measurement bridges. In fact, some configurations become linear.

The thermocouples can be used to measure fluid temperature, heat leakage, surface temperature, and so on. Rapid response of these sensors involves low weight and perfect contact with the surface which is measured. Measurements of fluid often requires a large area to take a medium reading. The connecting of transducer to the measured surface improves the response speed.

If a differential device is used to amplify the thermocouple signal, is recommended a source of ground for defining the level of common-mode input. This grounding point should be within the measuring point to avoid electrical gradients on the surface. It is often difficult to obtain a shielded cable and then the connections to the reference junction works often unprotected.

Because a reference junction is often used for more sensors, it has a parasitic coupling with local grounds if not using a protection system which must be linked to a medium point on the structure.

The differential temperature measurements do not require using of a reference junctions. The user need only to know the approximate temperature so that to be used the adequate voltage coefficients for certain thermocouple materials. The thermocells, on the other hand, requires that each thermocouple placed in series to have a connection to the same reference junction.

When the thermocouples are not linked to the structure, an ground connection appears like a false thermocouple. To avoid this problem is used a Wagner grounding. This configuration is shown in Fig. 1 and has two effects: balances the input conductors from the screen and sets the screen to the ground potential of source.

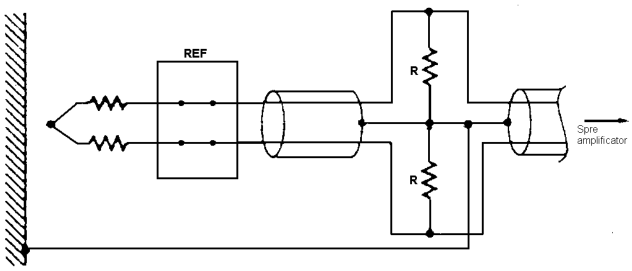

Fig. 1 Wagner connection of a thermocouple

Piezoelectric transducers are usually sources with capacitive reactance with a single end. The input cable must have a low noise and low leakage capacitive reactance. If the capacitance of transducer is of 1000pF and the noise is of 10μV, the nearby grounding must be attenuated by a factor of 100dB.

The voltage amplifiers are often used to amplify the signals from piezoelectric transducers. Their disadvantage consists in the signal attenuation depending on cable length. It is interesting to know that, as the cable length increases with the signal-noise ratio is low. The cable length must be standardized if there is to know precisely the signal attenuation. The voltage amplifiers are equally sensitive to the noise of the input cable as the amplifiers with load.

III. EXPERIMENTS USING DIGITAL SYSTEM

Acquisition system uses a Sigma-Delta converter with high resolution (22 bits). To achieve the maximum resolution, the features of this converter required to set a sampling rate maximum of 10 readings per second. If desired a quicker reading this may be decreasing the converter resolution (the least significant bits of the code word is not evaluated). This is why the interval between two readings was set to 100 ms.

In the experimental determinations were taken through the software the following data:

- the number of samples used to evaluate noise;
- the reading rate of analogic signal from the converter input (rate which not affect the measurement if we think that the recorded temperature has a low rate of change);
- the numeric code obtained by conversion at the ANC output;
- the percentage of the input voltage from the value of the ANC input value range;

- the rms value of the noise made by the ANC;
- the temperature in Celsius degrees at which the sensor was during the determination;
- the feature of the sensor connection at the input of the digital acquisition system;
- the name of the file where were saved the data.

Although the measured temperature was kept constant, due to the sensor error and due to the noise, the digital code at the output of analog-to-digital converter is different.

Determinations were made in three different cases:

- unshielded sensor connections;
- sensor with connections shielded but with the unconnected shield;
- sensor with shielded connections and connected shield.

An integrated senzor of LM35 type was used in an assembly which allow the measurement of the environment temperature in the area (-50 to 150) °C and which can measure the temperature of some non-corrosive liquids in the areas near the boundary.

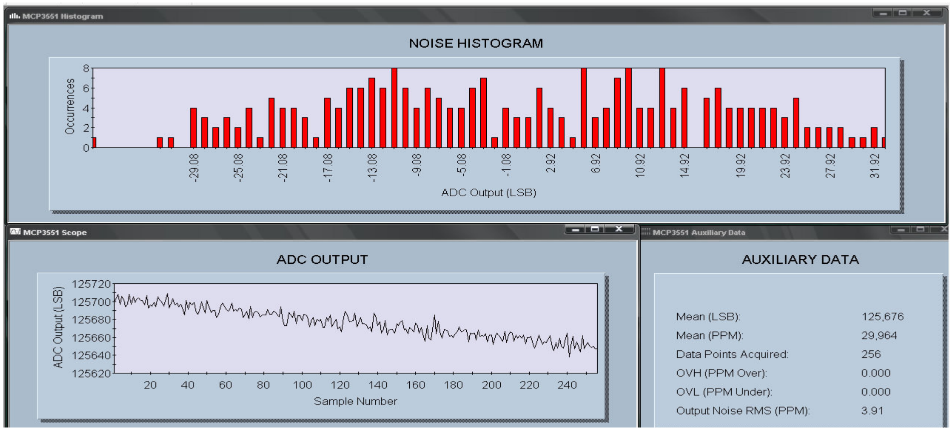

Fig. 2 Screen capture with 256 accuracy points (without shield)

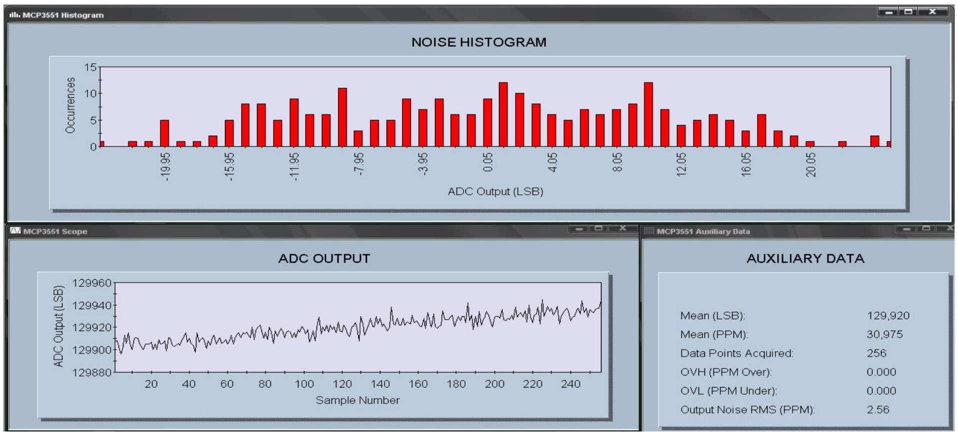

Fig. 3 Screen capture with 256 accuracy points (ungrounded shield)

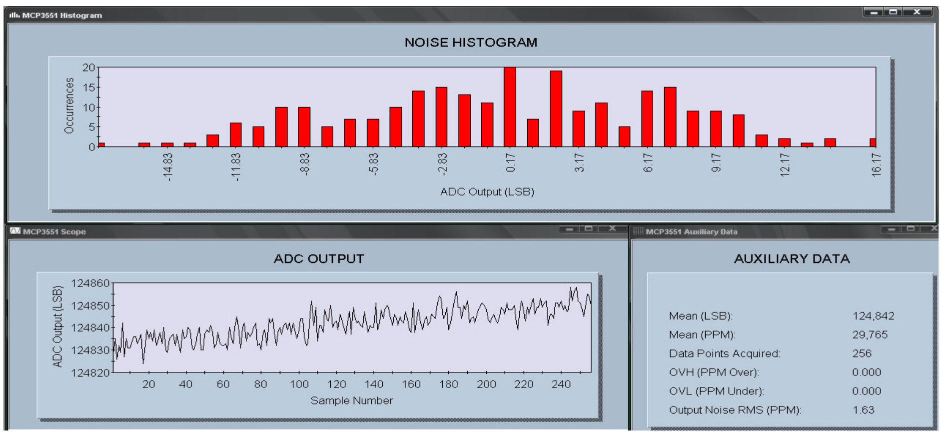

Fig. 4 Screen capture with 256 accuracy points (grounded shield)

IV. CONCLUSION

A first general conclusion that emerges from the paper is that in practice, of desire to obtain accurate measurements, we purchase high-resolution acquisition systems without taking into account that such a system is more sensitive to disturbance. Such a purchase is not recommended not only because of high cost but for the fact that such a system increases the errors from sensors by overlapping some signals of noise type over the useful signal.

After the made determinations results that for a high precision measurement system must that the errors of sensitive element to be in the same range of variation as the precision of the acquisition system. The accuracy of the acquisition system is given by the resolution of the analog-to-digital converter, by its linearity errors and by the errors given by the reduced acquisition times.

As shown in Fig. 4, even for a system with higher performances, the shielding of connections and of system against the harmful electromagnetic field has an important role. The share a proper shielding has on measurement results increases with the resolution of the digital acquisition system, can reach up to 30% for small signals and an analog-to-digital converter of 22 bits.

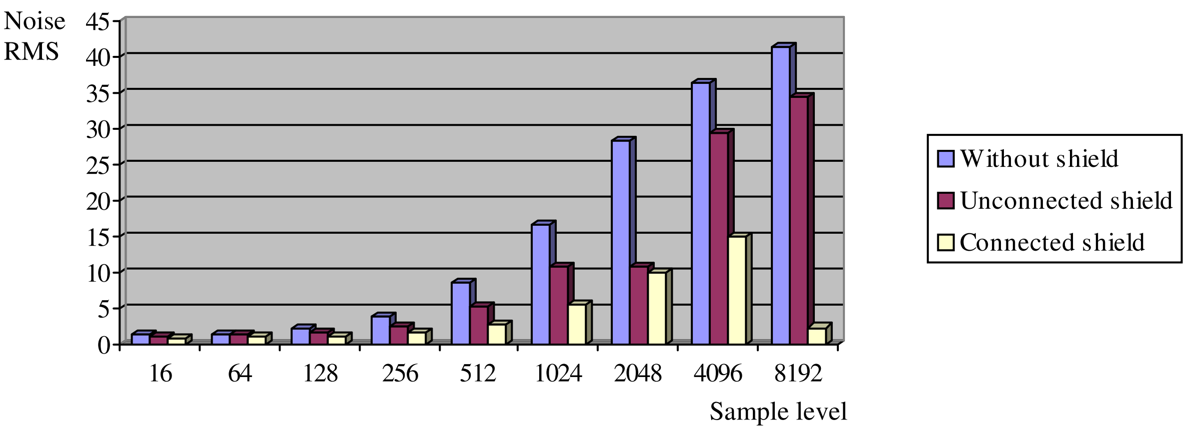

Fig. 5 Graphical representation of numerical values obtained from tests

Besides an appropriate choice of shielding method and of shields, in case of high resolution measurements it is recommended to use additional techniques to eliminate harmful tensions, as mediation and filtering software techniques, techniques that can improve the measurement quality by 20-30% for the case of a highly disturbed environment.

Technology has allowed today executing the instruments by a computer. Amplifications, deviations, filtering, calibration, scaling, balancing and so on can be controlled remotely. Discrete component of this control make that these instruments are expensive. In the future, technology will continue to supply components becoming smaller and increase the complexity of logic functions. These changes will reduce control costs by using computer. Finally, the economy curves will be crossed and the instruments made by computer will be used widely.

The effort made to design high-precision transducers will continue. In some cases, transducers are now available in version in that can be used directly without further conditioning. Classical problems, until now of common-mod, of excitation and so on, still limit the applications of these devices. Even the latest generation transducers require filters if the output signal going to be sampled.

There is currently a general tendency to avoid all analogic processes. A data acquisition system that is fully digital now seems to be the best solution. Transducers which provides the output digital data can be constructed. Such data can be queried by a bus system for further processing. This approach sends the whole analogic problem to the transducers manufacturer.

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REFERENCES

[1] J. Goedbloed. Electromagnetic Compatibility, Prentice Hall, London, U.K. , 1990.

[2] R. Morison. Grounding and shielding Techniques in Instrumentation, John Wiley, 1986.

[3] S. Morris Alan. Principles of measurement and instrumentation, second edition, Prentice Hall, London, 1993.

[4] D. Weston. Electromagnetic compatibility – Principles and Applications, Marcel Dekker, 2001.

[5] Milici M.R., Mihai I., Milici D., “Aspects of Engineering Education in Signal Technology Using Virtual Instrumentation”, The journal “Electronica ir Electrotechnika, no.6(94), pp.113-116, 2009.

[6] Rață M., Rață G., Milici D., Graur I., “An Efficient Solution of the Step-down Converter for Students Teaching” Electronics and Electrical Engineering, Number 3 (91), pp. 77-80, 2009.