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doi:10.15199/48.2015.07.10

Electromagnetic compatibility of electronic scales

***Abstract**. This paper describes problem of electromagnetic compatibility of electronic scales. This kind of electronic device is used for very precise weight measurements, e.g. in pharmacy or human weight measurement. Due to existing electromagnetic stresses it is strongly recommended to proof if its immunity is enough for operation in desired electromagnetic environment. This task is based on normative regulations and often device need to be equipped with some kind of protection measures.*

***Streszczenie**. Poniższy artykuł opisuje problematykę kompatybilności elektromagnetycznej elektronicznych wag pomiarowych. Tego typu urządzenia elektroniczne służą dokładnym pomiarom masy, np. w zastosowaniach aptecznych lub wagach osobowych. Ponieważ środowisko elektromagnetyczne zawiera różnego rodzaju narażenia stąd zalecane jest przeprowadzenie badań weryfikujących poziom odporności takiej wagi. Badania te oparte są o regulacje normatywne, a często kończą się one koniecznością wyposażenia urządzenia w dodatkowe środki ochrony. (**Kompatybilność elektromagnetyczna wag elektronicznych**).*

Keywords: electromagnetic compatibility, electronic scales, normative investigations, electromagnetic protection measures
Słowa kluczowe: kompatybilność elektromagnetyczna, waga elektroniczna, badania normatywne, środki ochrony elektromagnetycznej

Introduction

Along with the technological advances decisions made by humans are increasingly dependent on information's provided by surrounded electronic equipment. This concern not always the very complex devices, such as computers, but sometimes they may be much simpler, such as the electronic scales. Their contemporary structures are significantly different from those we know from the past, and their range of use is very wide due to the easy adaptation in automated production and high importance in everyday applications. Mechanical springs have been replaced with sensors which converts the bar deflection into electrical signal. The complex microprocessor systems perform weight calculations. Unfortunately processed information can be disturbed during the conversion of the bar deflection, as well as in the further on stages, up to the final value appearing on the display. Very often, the problem sneaks in each of these stages. In consequence it accumulates itself in the final result. In the modern world there are many electromagnetic threats that could lead to malfunctioning of the sensitive elements and to wrong measurement. The ability of this kind of scales to work properly in this environment is defined by electromagnetic compatibility (EMC) and characterized by the level of immunity. In practice, the assessment of this ability is done with several immunity tests in which the equipment is disturbed with the severity levels specified in the national and international standards, and then observing if the indications are correct or not. This paper describes exemplary electromagnetic requirements for electronic scales, test procedures, obtained results and drew conclusions and applied protection measures.

Construction of electronic scale

One of many types of medical electronic scales used for measurement of human weight was taken under consideration. This one was built with two modules: mechanical with inductive sensor and electronic Printed Circuit Board with the user interface. They were connected one to another by multi wire unshielded twisted pair cable. The device might be powered by external source (AC/DC power adaptor) or from built-in battery.

In figure 1 the functional diagram of the tested scale is presented. As the input value weight force converted to the aluminum bar deflection with the factor k_1 is taken. The next element is the amplifier with the factor k_0, then the voltage to current converter with the factor k_3, the current of which is fed back via the servomotor with the factor k_4 to the input connector. Device under tests is presented in fig. 2.

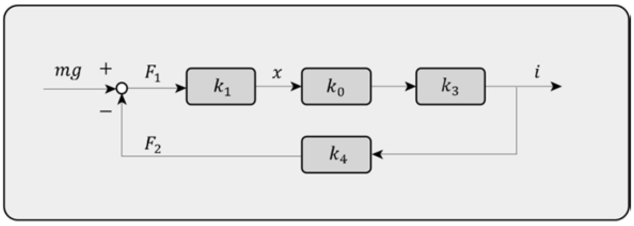

Fig. 1 The block diagram of the tested scale.

The scale is ungrounded (II class device), so it means it is powered by only L and N conductor.

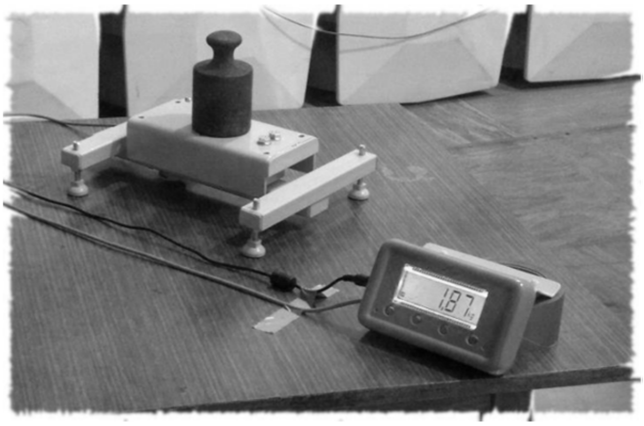

Fig. 2 Device under tests.

Electromagnetic requirements

This kind of devices should fulfill the requirements published in the standard EN 45501 [1], especially if their producer want to obtain a certificate of electromagnetic compatibility. In this standard four sets of disturbances, which should be applied to device are described:

- electrostatic discharges (ESD)
- electrical fast transient impulses (EFT/Burst)
- power quality test (PQT)
- radioelectric disturbances

Due to electromagnetic environment for which this device is designed the tests should be performed with the severity level 3. It means voltage amplitude 6 kV for direct (by contact) discharges and 8 kV for indirect (by air) discharges for the ESD test. For the EFT/Burst the impulse features are collected in the table 1 and table 2, depending on the line under test (power or signal).

Table 1 Parameters of EFT/Burst pulses coupled to the power line.

Parameter name	Value
Voltage level	1 kV
Impulse frequency (impulse width)	5 kHz
Number of pulses in the package	75
Duration of the package	15 ms
Repetition time of the package	300 ms
Duration of the test	1 min

Table 2 Parameters of EFT/Burst impulses coupled to the signal line

Parameter name	Value
Voltage level	0,5 kV
Impulse frequency	5 kHz
Number of impulses in the package	75
Duration of the package	15 ms
Repetition time of the package	300 ms
Duration of the test	1 min

For the PQT tests the disturbance levels were defined as voltage lowered to 70%, 40% and 0% of rated voltage level (230 V) with the maximal event time 2 cycles (40 ms).

Because of lack of the measurement equipment only the first three mandatory tests were done, but additionally the surge immunity test was performed. It is not necessary for this device, but in general required in many cases for other electronic devices. The voltage level was set on 1 kV / 2 Ω for the power line and 0,5 kV for the signal line. For power line pulses were coupled by direct injections, but for signal line with capacitance coupler[1]. This kind of disturbances may be caused by lightning discharge to ground and by accompanied lightning electromagnetic pulse (LEMP), which may induced voltages in the inside installations [2,3,5].

Test results

Obtained results reveals some problems with stable operation of the tested scale. The one and significantly disturbing were the EFT/Burst pulses. The three remaining tests resulted with no influence on the scale and proved compatibility with the requirements defined in the standard [1].

The results obtained during the EFT/Burst tests in case of power line are collected in table 3.

Table 3. Results of EFT/Burst tests in case of power line.

Line	Impulse polarization	Observation results
L-GRP[2]	+	Short periods with no possibility to read measurements
	–	
N-GRP	+	
	–	Lack of stable readings during whole test time
(L-N) -GRP	+	
	–	

Above coupling configurations are mandatory due to normative papers. Effect of the EFT/Burst disturbances on the signal line connecting the electronic with the mechanical part was short variations of measurements values displayed on the screen and short time periods without possibility to make proper readings of the measured weight. This effect exists for both polarizations. Observed results are no permissible by the standard [1] and some kind of measures should be applied. Exemplary oscillograms of the signals are presented in figures 3-5.

Problem solutions and verification

Based on the obtained results the ways were investigated which possibly may reduce disturbances and may the scale to fulfill the standard [1] requirements. In this paper it will be described on example of communication cable, but the results observed in the power cable were very similar. Because of the size of the scale especially screening of the cables or ferrite rings were taken for investigations. After few tests the best of them has proven to be the set of ferrite rings mounted on one end (closer to the electronic interface) of the communication cable. Researches for various types and parameters of the Kitagawa ferrite rings were carried out. Datasheet parameters used ferrite rings are collected in table 4.

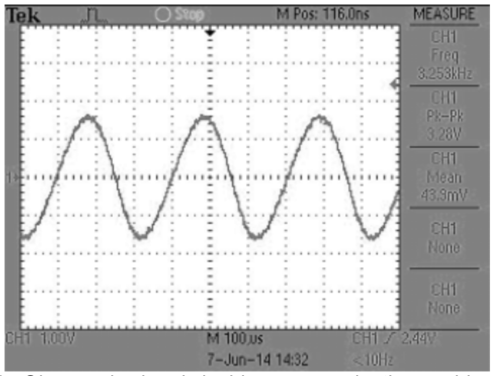

Fig. 3 Observed signal inside communication cable without disturbances.

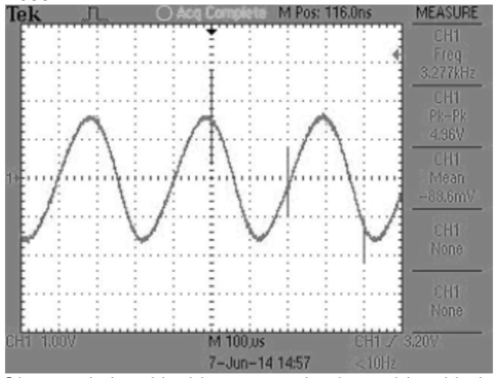

Fig. 4. Observed signal inside communication cable with the EFT/Burst disturbances (wide time window).

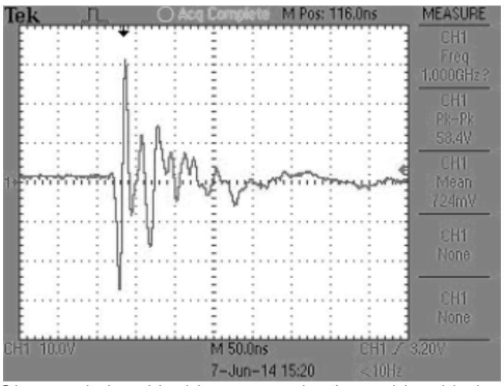

Fig. 5 Observed signal inside communication cable with the EFT/Burst disturbances (short time window).

Table 4 Ferrite rings datasheet parameters.

		Impedance [Ω]	
Number of the ferrite ring	Description (type)	for 25 MHz	for 100 MHz
1	TRCN-16-8-16	64	106
2	TRCN-28-16-02	56	90
3	TR-16-8-13	79	127
4	SFC-6	139	207
5	TFC-16-8-13	73	139

1 One of the standard EMC Best generator equipment
2 GRP – Ground Reference Plate

Due to various ferrite characteristics various effectiveness were obtained. The results are presented in figure 6.

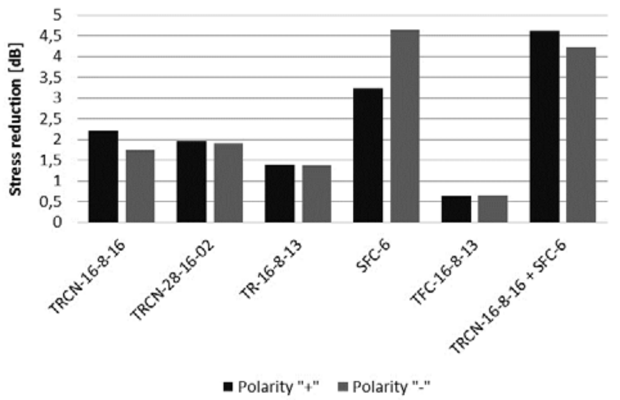

Fig. 6 Effectiveness of tested ferrite rings.

As we can observe the best results defined as the maximum stress reduction were obtained for two types of ferrite rings: SFC-6 and pair of TRCN-16-8-16 with SFC-6 in series (figure 7). Because of the cable radius there were no possibility to wind more coils.

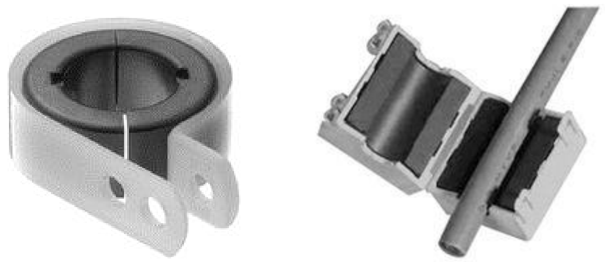

Fig. 7. Photography of ferrite rings with the best results during tests [4].

In case of cable screening by placing it inside the conducted steel mesh, with both ends connected to conducted parts of the tested device (metal construction of the scale) the observed effectiveness was poor, probably because of poor solution of the equipotential connection between both parts of the scale. One of them – PCB with processor and display - is digital and another – with inductive sensor – is analog, so the high frequency disturbances interfere the useful signal despite screening.

Conclusion

The problem with electromagnetic compatibility of electronic devices is more and more actual in the human lives. Even in such simple case as presented above - in weight measurement. Used devices are more complicated in their structures and consecutively the immunity levels of various kind of disturbances are relatively smaller. On the other hand the electromagnetic environment contain increasingly disturbances, so the probability of undisturbed operation is smaller. This gives motivation to perform the tests prescribed in standards, sometimes with the higher severity levels, as it is presented here. In some situations during electromagnetic testing the electronic scales sensitivity for coupled disturbances is permissible, but the scale should inform about bad reading. In our case the tested scale was not equipped with this function, so the general requirement was set up at higher level. Making this tests we got information which elements of the devices should be improved before placing device on the market. Sometimes unnecessary hazardous of the users can be avoided in this way.

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