Agronomy Research **17**(2), 438–446, 2019
https://doi.org/10.15159/AR.19.093

Measurements of wireless detectors used to monitor animal movements in livestock farms

J. Hart[1,*] and V. Hartová[2]

[1]Czech University of Life Sciences Prague, Faculty of Engineering, Department of Technological Equipment of Buildings, Kamýcká 129, CZ165 00 Prague, Czech Republic
[2]Czech University of Life Sciences Prague, Faculty of Engineering, Department of Vehicles and Ground Transport, Kamýcká 129, CZ165 00 Prague, Czech Republic
[*]Correspondence: janhart77@gmail.com

Abstract. At present, there is a great interest in monitoring and automating farm animals and livestock farming. There are many systems and methods to check the movement of animals in certain areas. One option is to use motion detectors. However, some installations are so specific that they require the use of wireless motion detectors. They not only have to fulfill their functional part but also have a sufficiently strong signal that should not interfere outside the defined ISM bands. Due to the frequent deployment of different types of these detectors, research has been carried out to monitor shortcomings in frequently used types of wireless detectors. This research defines which tested detectors are fully usable according to the standards and which need to be modified by the manufacturer. Also, based on measurements, the basic risks and recommendations for the use of individual types of tested detectors are defined.

Key words: livestock, measurement, wireless, ISM band, detector.

INTRODUCTION

At present, there is a great interest in monitoring and automating farm animals and livestock farming. There are many systems and methods to check the movement of animals in certain areas. These methods can be divided into contact and non-contact. Contact methods can use different systems, such as pedometers or RFID technology (Porto et al., 2012). These detections can affect the comfort of animals and must be placed on each monitored place. If only a passage is required to be monitored, so-called non-contact measuring systems, such as laser gates, infrared gates, and others, are also used. All of these monitoring systems are part of so-called systems to maximize animal welfare (Firk et al., 2002; Barbari et al., 2008; Martiskainen et al., 2009; Ilie-Zudor et al., 2011; Alsaaod et al., 2012; Chanvallon et al., 2014).

One of the possibilities for non-contact detection is the use of passive motion detectors. However, there is a problem with the fact that only wireless detectors can be installed in certain locations. These detectors may not only meet the requirements for a given measurement but also require wireless transmission (Mathie et al., 2004; Robert et al., 2009; Ilie-Zudor et al., 2011; Alsaaod et al., 2012; Chanvallon et al., 2014).

ISM bands (Industrial, Scientific and Medical) are typically used for wireless transmission. Many researches have shown that not every transmitter meets the ISM band. These bands are free of charge and are specified by the telecommunication authorities. It was therefore a question of whether motion detectors meet the necessary requirements of telecommunication authorities. Failure to meet the requirements would lead to complications in their installation. (Kuchta et al., 2009; Nikonowicz et al., 2019; Zgaren et al., 2018; Yang et al., 2018).

Aim of the paper was of whether the selected wireless detectors meet the requirements for wireless communication in the ISM bands. An evaluation was also made based on the wireless transmitting intensity of individual motion detectors (Kuchta et al., 2009; Schmidt et al., 2017; Hart & Hartová, 2018; Nikonowicz et al., 2019).

MATERIALS AND METHODS

Test were performed accurately to determine the breadth of broadcast for each motion detector. Motion detectors for which the tests were conducted are standard motion detectors used to frequent occurrence. These are the following types:

ISM868: JA-83P, PMD75, PMD2P, IR8M, RWT95P

ISM433: PMD75, AZ-10P.

SPECTRAN HF-6060 spectrum analyser (Fig. 1) was used, which investigated the size of the frequencies at tested motion detectors. Within the measurement the following values were set on the SPECTRAN HF-6060 spectrum analyzer:

- Sampletime – 50 ms
- Samples – 500
- Bandwidth – 1 MHz

Figure 1. Spectrum analyser SPECTRAN HF-6060 with an antenna.

At the beginning of the measurement, the hypothesis 'The wireless signal base is in the ISM433 (433–434,79 MHz) or ISM868 (868–870 MHz) band' is determined. The measurements were made by the detector being installed in a laboratory 4 m from the spectral analyzer. When the detector was in the state of guarding, there was a disturbance of the guarded space (moving in front of the detector). Detected signals were also recorded through a spectral analyzer into the MSC SpectrumAnalyzer software. Subsequently, a graph of transmission characteristics was created with the help of the software. Measurement was performed on all motion detectors cyclically and measured at least 500 cycles.

The Figs 2–10 show the intensity of the wireless transmission motion detectors in bandwith ISM868. Among these figures, Figs 3, 5, 7 and 9 show the origin of the transmitted signal range for individual motion detectors.

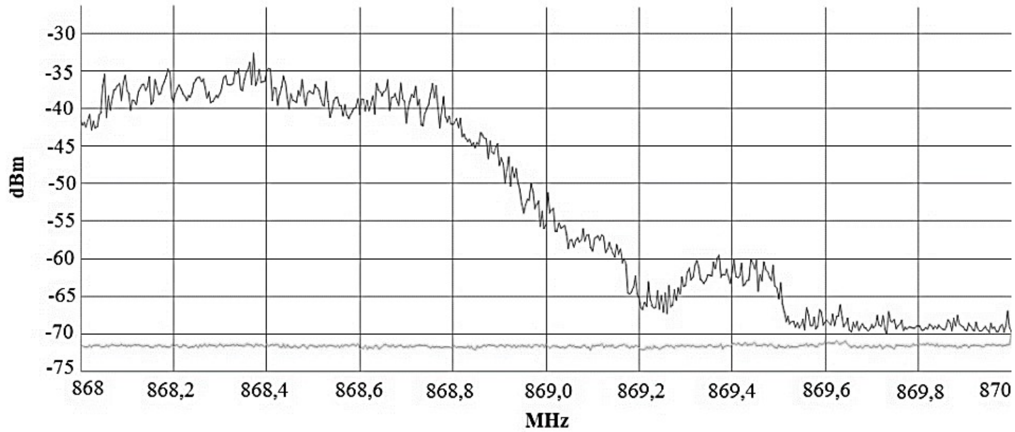

Figure 2. Motion detector JA-83P (ISM bandwidth).

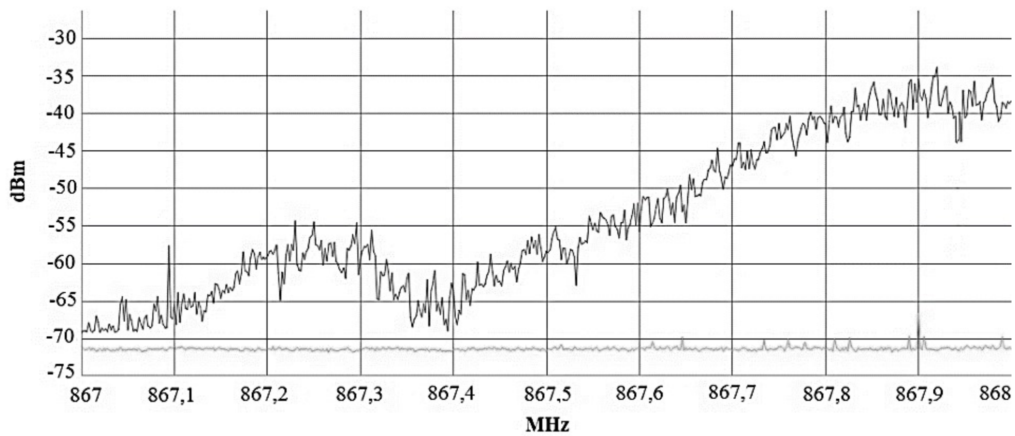

Figure 3. Motion detector JA-83P (origin of the transmitted signal range).

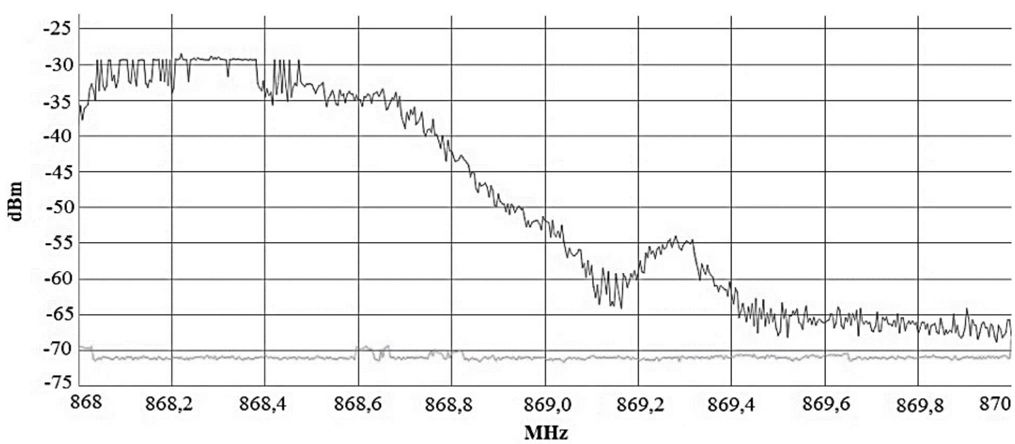

Figure 4. Motion detector PMD75 (ISM bandwidth).

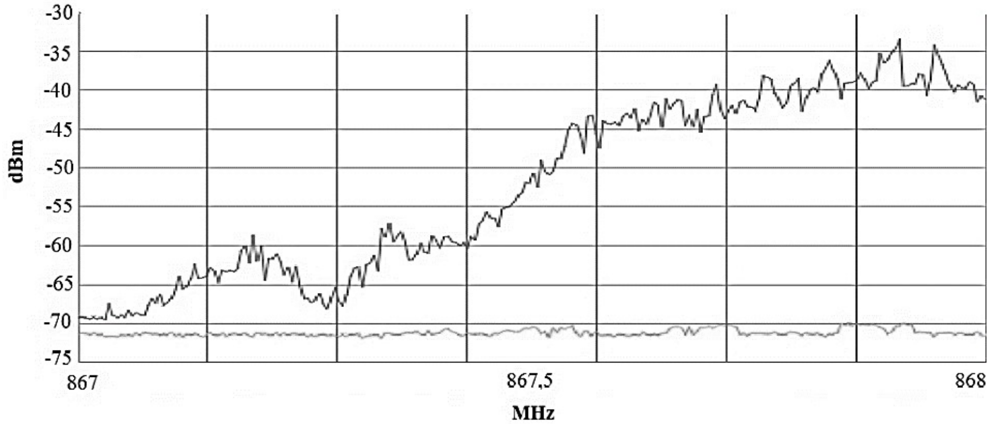

Figure 5. Motion detector PMD75 (origin of the transmitted signal range).

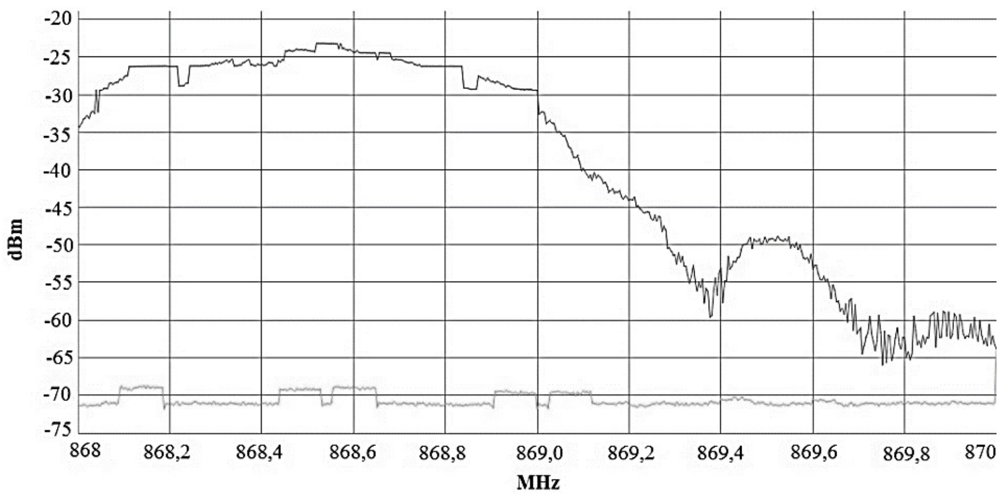

Figure 6. Motion detector PMD2P (ISM bandwidth).

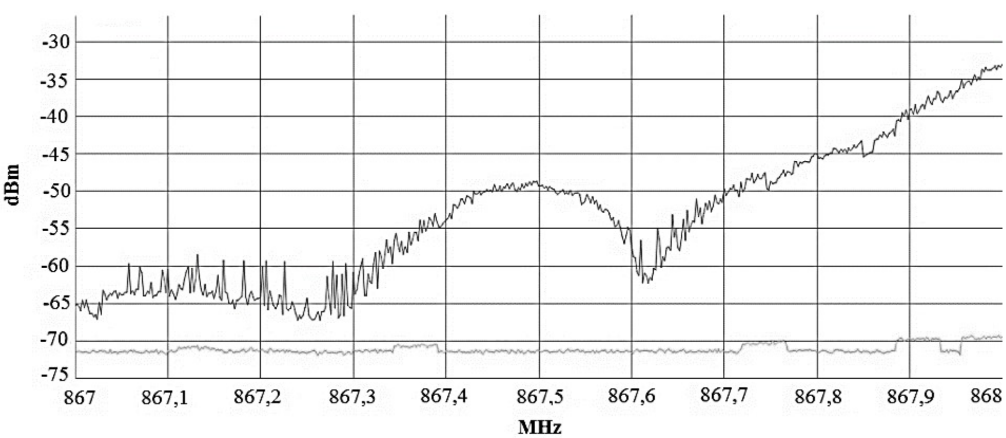

Figure 7. Motion detector PMD2P (origin of the transmitted signal range).

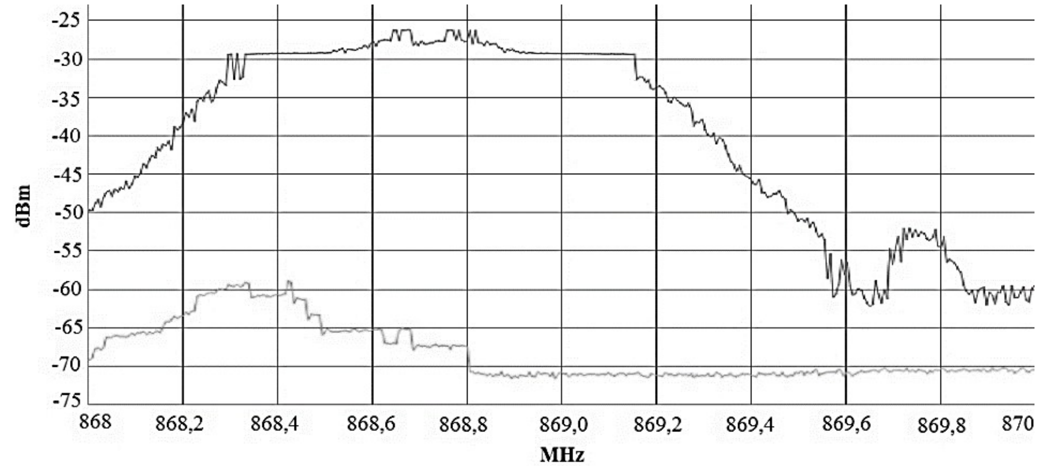

Figure 8. Motion detector IR8M (ISM bandwidth).

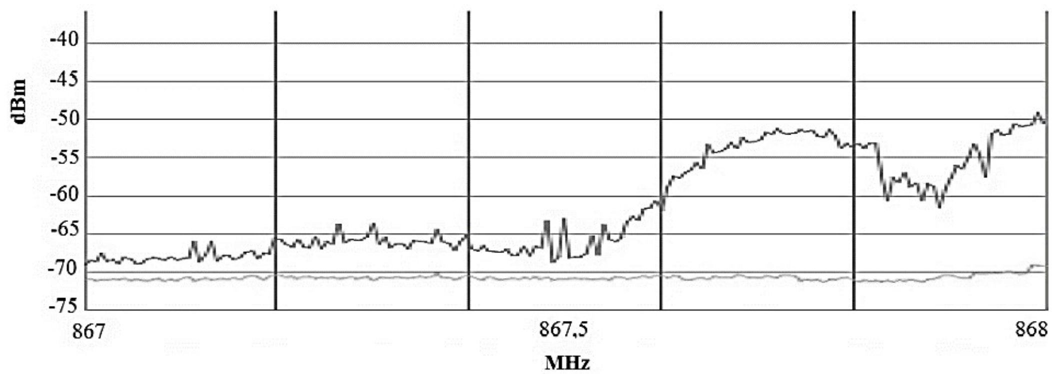

Figure 9. Motion detector IR8M (origin of the transmitted signal range).

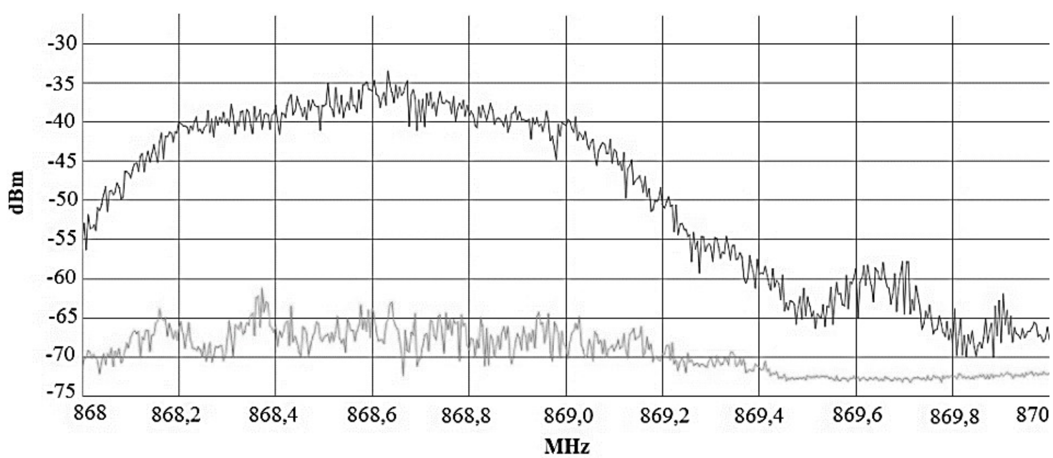

Figure 10. Motion detector RWT95P (ISM bandwidth).

The Figs 11 and 12 show the intensity are an evident intensity of the wireless transmission motion detectors in bandwith ISM433.

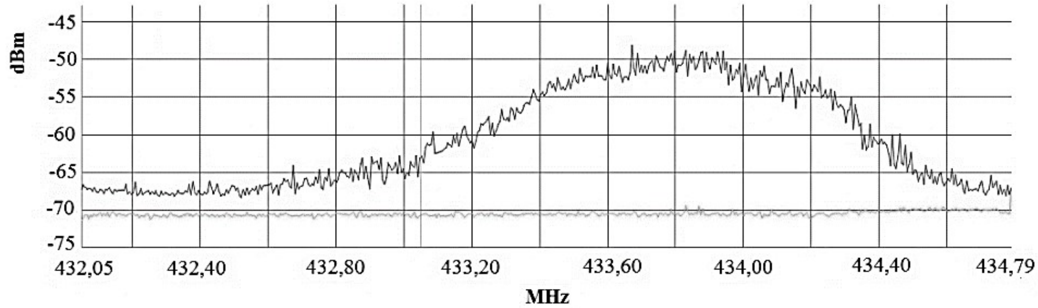

Figure 11. Motion detector PMD75 (ISM bandwidth).

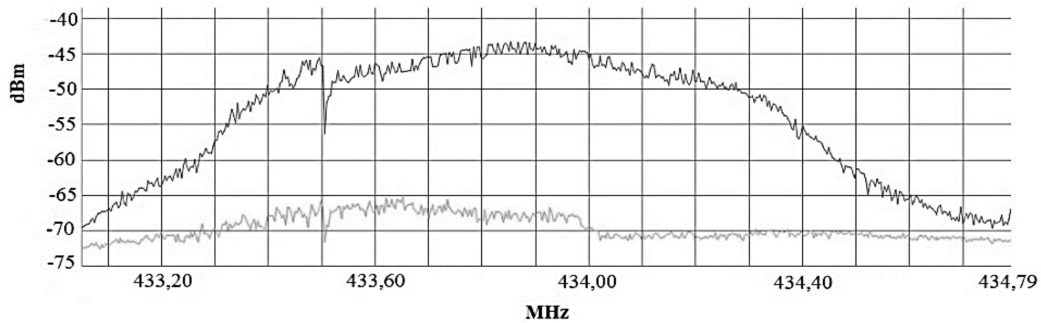

Figure 12. Motion detector AZ-10P (ISM bandwidth).

In the following figures (Figs 11 and 12) are an evident intensity of the wireless transmission motion detectors in bandwith ISM433.

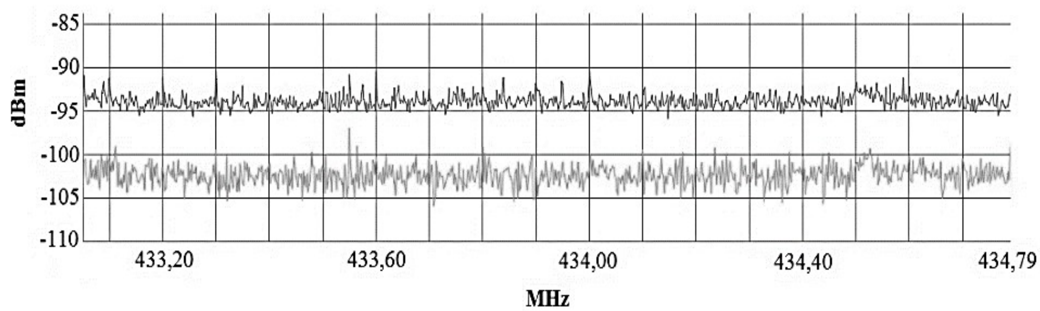

Figure 13. Motion detector AZ-10P (ISM bandwidth).

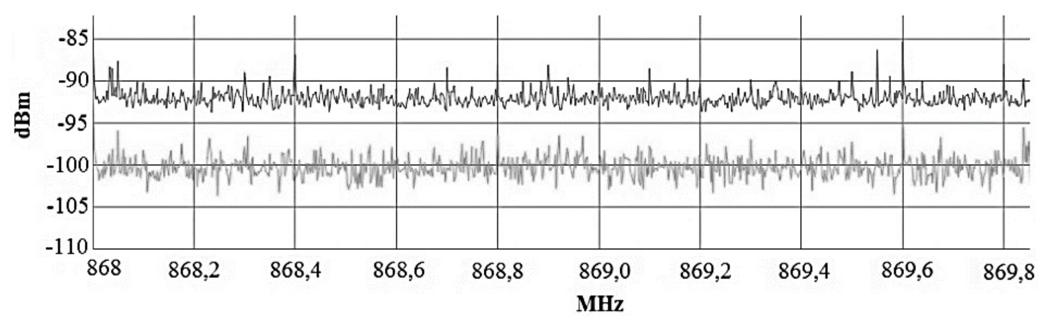

Figure 14. Motion detector AZ-10P (ISM bandwidth).

RESULTS AND DISCUSSION

All charts show two values, referred to the maximum measured value and the current trend. For detector measurements, the maximum value of the detector transmission is given. For ISM band measurements, the maximum value is the limit over which it is normally possible to transmit.

It is obvious that all tested detectors meet signal intensity. According to the measurement of natural interference in a given area (Figs 13 and 14) it is obvious that all tested detectors have higher signal strength. It was found that the JA-83P, PMD75, PMD2P and IR8M detectors did not meet the requirements of the ISM bands and hit their part beyond the defined values (Figs 3, 5, 7 and 9).

The evaluation of the individual criteria, which are the signal strength, the base of the transmission signal and the exact range defined by the ISM bands, can be seen in Fig. 15. The graph was created by a multi-criteria point analysis of variants. The ratio between the criteria evaluated was: exact range defined by the ISM bands (0.5), the signal strength (0.3) and the base of the transmission signal (0.2).

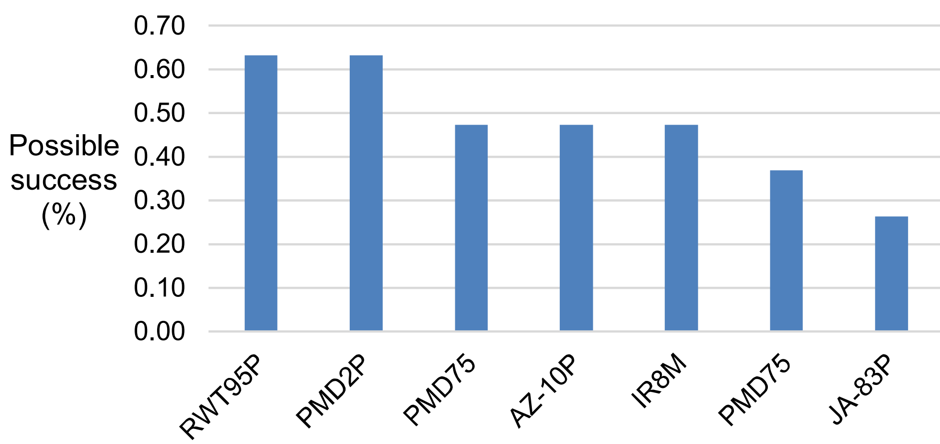

Figure 15. The evaluation of the individual criteria at motion detectors.

Possible success has been identified. This is the percentage of intensity, width and meeting the scope of ISM wireless transmission. Although two detectors (RWT95P and PMD2P) were placed in the first place, it can be determined that the detector RWT95P is better. This is because it meets the ISM868 transmission band.

In the past, many tests have been carried out on different systems that have proven that not every manufacturer adheres to the exact range of ISM bands. For the proper functioning of cattle pass testing, it is advisable to use motion detectors that meet the requirements for their use. The use functional detectors that do not have a well defined ISM band can result in the need to uninstall the system. This initiative may arise from a telecommunication office that can evaluate the system being used as a disruptive element in a given area (Kuchta et al., 2009; Schmidt et al., 2017; Hart & Hartová, 2018; Zgaren et al., 2018; Yang et al., 2018; Nikonowicz et al., 2019).

CONCLUSIONS

On the basis of this study, some conclusions can be taken. It is important to have an overview of the reliability and functionality of each wireless transmissions. When using wireless transmissions, it is also important for motion detectors to have bidirectional communication, which increases the system's chances to detect band interference, and also allows the transmission to be switched to a free zone.

The RWT95P is the best-rated detector due to its features. Detectors JA-83P, PMD75, PMD2P and IR8M detected overlapping outside ISM bands. It is therefore recommended to change the wireless technology of these detectors.

All of the measured data are important for end users and manufacturers as feedback on their products. In the future, there will be efforts to expand similar tests to other manufacturers, as the reliability of these systems is very important, and it will be necessary to check them.

ACKNOWLEDGEMENTS. It is a project supported by the CULS IGA TF 'The University Internal Grant Agency' (31170/1312/3121).

REFERENCES

Alsaaod, M., Romer, C., Kleinmanns, J., Hendriksen, K., Rose-Meierhofer, S., Plumer, L. & Buscher, W. 2012. Electronic detection of lameness in dairy cows through measuring pedometric activity and lying behavior, In: *APPLIED ANIMAL BEHAVIOUR SCIENCE*, pp. 134–141.

Barbari, M., Conti, L. & Simonini, S. 2008. Spatial identification of animals in different breeding systems to monitor behaviour. *Proceedings of the VIII Congress on Livestock Environment*. Iguassu Falls, Brazil, 31 August-4 September, 937–942.

Chanvallon, A., Coyral-Castel, S., Gatien, J., Lamy, J.M., Ribaud, D., Allain, C., Clement, P. & Salvetti, P. 2014. Comparison of three devices for the automated detection of estrus in dairy cows, In: *THERIOGENOLOGY*, pp. 734–741.

Firk, R., Stamer, E., Junge, W. & Krieter, J. 2002. Automation of oestrus detection in dairy cows: a review, In: *LIVESTOCK PRODUCTION SCIENCE*, pp. 219–232.

Hart, J. & Hartová, V. 2018. Testing of ISM band at remotes for unlocking vehicles. *Agronomy Research* **16** (S1), 1017–1024.

Ilie-Zudor, E., Kemeny, Z., van Blommestein, F., Monostori, L. & van der Meulen, A. 2011. A survey of applications and requirements of unique identification systems and RFID techniques, In: *COMPUTERS IN INDUSTRY*, pp. 227–252.

Kuchta, R., Vrba, R. & Sulc, V. 2009. IQRF Smart Wireless Platform for Home Automation: A Case Study, In: 5*th International Conference on Wireless and Mobile Communications*, Cannes, France, pp. 168–173.

Martiskainen, P., Jarvinen, M., Skon, J.P., Tiirikainen, J., Kolehmainen, M. & Mononen, J. 2009. Cow behaviour pattern recognition using a three-dimensional accelerometer and support vector machines, In: *APPLIED ANIMAL BEHAVIOUR SCIENCE*, pp. 32–38.

Mathie, M.J., Coster, A.C.F., Lovell, N.H. & Celler, B.G. 2004. Accelerometry: providing an integrated, practical method for long-term, ambulatory monitoring of human movement, In: *PHYSIOLOGICAL MEASUREMENT*, pp. R1–R20.

Nikonowicz, J., Mahmood, A., Sisinni, E. & Gidlund, M. 2019. Noise Power Estimators in ISM Radio Environments: Performance Comparison and Enhancement Using a Novel Samples Separation Technique, In: *IEEE TRANSACTIONS ON INSTRUMENTATION AND MEASUREMENT*, pp. 105–115.

Porto, S.M.C., Arcidiacono, C., Cascone, G., Anguzza, U., Barbari, M. & Simonini, S. 2012. Validation of an active RFID-based system to detect pigs housed in pens. *J. Food, Agriculture & Environment* **10**(2), 468–472.
Robert, B., White, B.J., Renter, D.G. & Larson, R.L. 2009. Evaluation of three-dimensional accelerometers to monitor and classify behavior patterns in cattle, In: *COMPUTERS AND ELECTRONICS IN AGRICULTURE*, pp. 80–84.
Schmidt, M., Block, D. & Meier, U. 2017. Wireless Interference Identification with Convolutional Neural Networks, In: *2017 IEEE 15TH INTERNATIONAL CONFERENCE ON INDUSTRIAL INFORMATICS (INDIN*), pp. 180–185.
Yang, H., Kim, B., Lee, J., Ahn, Y. & Lee, C. 2018. Advanced Wireless Sensor Networks for Sustainable Buildings Using Building Ducts, In: *SUSTAINABILITY*, Ar. Num. 2628.
Zgaren, M., Moradi, A., Tanguay, L.F. & Sawan, M. 2018. ISM-band 902-to 928-MHz FSK transceiver with scalable performance for medical devices, In: *INTERNATIONAL JOURNAL OF CIRCUIT THEORY AND APPLICATIONS*, pp. 2266–2282.