Agronomy Research **16**(2), 410–415, 2018
https://doi.org/10.15159/AR.18.067

Improvement of monitoring of cattle in outdoor enclosure using IQRF technology

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Abstract. Monitoring of cattle in the outdoor enclosure is a very important issue. Currently, the increasingly stealing cows and other cattle from the pasture. For businesses that manage it, this is a very lossy business. For thieves, the electric fences, which are currently the most widespread, are easily surmountly. And the owner does not have a chance early on to learn the fact theft of cattle. For this reason, a system for monitoring cattle on outdoor enclosure using IQRF (intelligent local network topology) technology has been developed. We have been dealing with this issue for a long time and the biggest problem was the monitoring of only the inner part of the enclosure. Previously, there was an overlap of monitoring in the area beyond grazing. This problem has been solved by using a shielded base for mounting IQRF receivers.

Key words: IQRF technology, wireless transmission, interference, livestock.

INTRODUCTION

Wireless technologies are increasingly being used. Whether it is wireless transmission in surveillance systems, Wi-Fi networks, Bluetooth transmissions or various RC models, their transmissions are ubiquitous. All in all, they basically define the modern time and our civilization as such. Of course there are also many risks and imperfections related to wireless networks that need to be considered. One of the most frequent risks of wireless transmission is natural interference or a limited range of wireless transmitters. Though being serious, these problems have their realistic solutions provided by an IQRF MESH (intelligent local network topology) network which can at least partially eliminate them (Dong et al., 2013; Elmasry, 2013; Behkami et al., 2017).

As for the above mentioned technologies, ISM bands (industrial, scientific and medical) are mostly used for wireless transmissions. They are amply used in a variety of industrial transmissions. Officially, these bands should only be used for industrial, medical or scientific purposed. The Federal Communications Commission and the European Telecommunications Standards Institute established just the ISM bands as licence-free and given their licence-free usage they are also heavily preferred for commercial purposes (Tahir & Shah, 2008; Hartová & Hart, 2017).

It is therefore favourable to use these modern technologies in the licence-free ISM bands to protect livestock in such a way that attempts at their theft are detected in time. Although its purpose is clearly defined, following small modifications the resulting technology could also help in monitoring animal welfare (Kucera et al., 2015; Lopes & Carvalho, 2016; Hartová & Hart, 2017).

The problem was mainly to solve the directivity of the used receivers. It is necessary to limit the reception of the signal from the area outside the supervised area. This research builds on the already solved problem that was solved by Bloetooth: 'Livestock monitoring system using bluetooth technology' (Hartová & Hart, 2017).

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IQRF technology is one of the other communications representatives on radio frequencies and a potential participant in IoT combat. It was published in 2004 and is mainly devoted to Czech developers (Kuchta et al., 2009; Sulc et al., 2009; Bazydlo et al., 2015; Martin & Radovan, 2016).

The aim of the investigation was to design a livestock monitoring system. Based on the discovery of the deficiencies in the system's predecessor design, the detection technology was changed. At the same time a shielded pad was developed to correct the detected area.

MATERIALS AND METHODS

Following in-depth market research a technology conforming to exacting criteria for monitoring of livestock theft was selected. Due to the experience of the past, more flexible technology has been chosen than it was in the first place in preliminary studies (Hartová & Hart, 2017). IQRF technology (see Fig. 1) has replaced Bluetooth technology as it better meets the requirements of the overall system. The main demands placed on the transmitters were their low energy demands. In addition, their range of coverage was evaluated and therefore the IQRF technology was selected, which enables transfer on ISM868 bands (industrial, scientific and medical) (Hartová & Hart, 2017; Bazydlo et al., 2015; Kuchta et al., 2009; Sulc et al., 2009).

Figure 1. IQRF elements.

For LPWAN (Low-Power Wide-Area Network), it uses an atypical mesh topology instead of a star topology that is common for Sigfox or LoRa technologies. This choice has its plus and minus. It uses a specially created IQRF MESH protocol, which is integrated into the operating system's system for better and more efficient routing. This is a packet-oriented technology where the payload is at most 64 B but

where the actual size is given by the specific device requirements. The resulting range of such a network ranges in tens of kilometers (Kuchta et al., 2009; Sulc et al, 2009; Bazydlo et al., 2015; Martin & Radovan, 2016).

In the frequency spectrum, the technology is specified at frequencies of 868, 916 and 433 MHz. In these bands it uses a number of channels, which are different for all three frequencies. It also varies with the maximum transmit power at 433 MHz 5 mW and at 868 and 916 MHz at 3.5 mW (5.44 dBm). In the band around 868 MHz, which is most discussed here, the frequencies range from 863.15 to 869.25 MHz, corresponding to the European band g with subgroups g1 and g2. In the Czech Republic, it falls within band h with subgroups h1 and h2 under General Authorization. There are 62 channels with numbers from 0 to 61 with a standard 100 kHz bandwidth. Very often, channel 52 is used, which is a frequency of 868.35 MHz. These channels work at a transfer rate of 19,836 kbit s^{-1}, which is the most common transfer rate for IQRF system (Kuchta et al., 2009; Sulc et al., 2009; Bazydlo et al., 2015; Martin & Radovan, 2016).

A small farm was chosen for the purpose of designing the system, with an adjoining pasture for cattle – see Fig. 2. The same farm was selected as in the previous proposal. (Hartová & Hart, 2017)

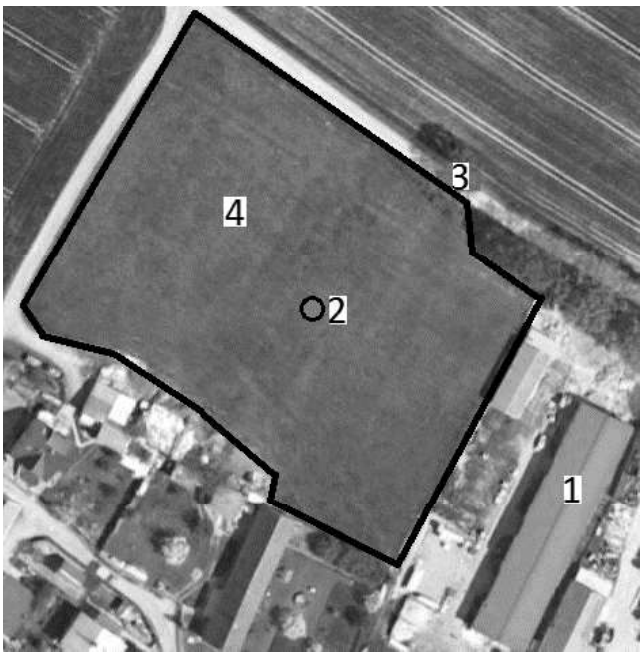

Figure 2. The chosen farm (1 – barn for housing cattle; 2 – location of centralized drinking troughs; 3 – fenced pastures; 4 – pasture).

The pasture was 100 m long and 70 m wide. There were 50 cows on grazing. Measurements took place throughout the year 2017. In our design of location of the receivers we have chosen the circuit procedure. By doing that we reached the optimal range of transmission of across the area, however with an effective wireless coverage even outside the supervised area. The distance of this effective transmission is referred to as the declared distance, which is considered a distance over which the transmission

should take place almost under any conditions. To reduce the declared distance of the receivers, a shielding socket was created (Hartová & Hart, 2017).

Detection of an animal loss is based on a simple principle. When an IQRF nod regularly sends data and the IQRF control unit receives regular messages of its presence from the given IQRF nod, this indicates that things are in order and no alarm is launched. There was a time window determined during which an IQRF nod must send a message at least once, and this was set to 5 seconds. On a standard basis it should report five times within this time, but an interference may occur thus this safeguard is set to prevent false alarms. As in previous research on the topic: 'Livestock monitoring system using bluetooth technology' (Hartová & Hart, 2017).

The size of the monitored areas is limited by the maximum number of nodes in the network. Each knot has a range of up to 500 m in free space. These networks may be displayed as several superstructures on top of each other, provided that frequencies are not disturbed. The area can take up to several tens of kilometers, depending on the structure.

RESULTS AND DISCUSSION

A problem of past research in the appeared when it came to outdoor grazing where animals can move beyond the determined area without raising alarm – see Fig. 2. This problem has remained unresolved in past research (Hartová & Hart, 2017).

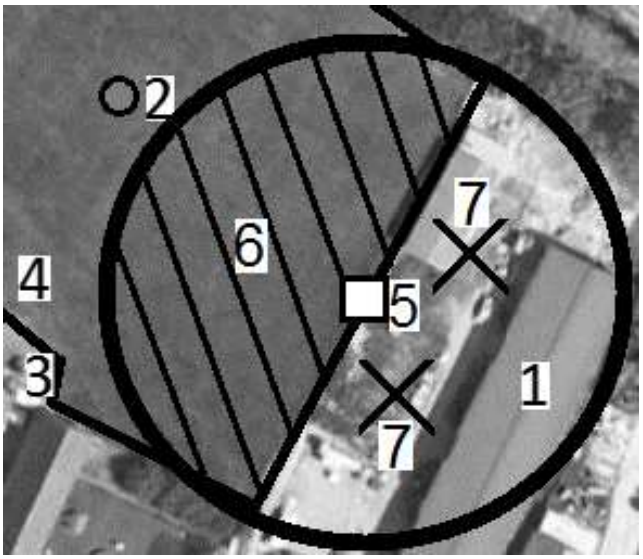

Figure 2. Section of chosen farm (1 – barn for housing cattle; 2 – location of centralized drinking troughs; 3 – pasture fencing; 4 – pasture; 5 – IQRF unit; 6 – monitored area; 7 – unmonitored area).

Due to the change of centralized monitoring to perimeter, technology change, and shielded pad development (see Fig. 3), we have made some changes. With these changes, we have achieved a minimum overlap outside the monitored area. We electrically ground and separate the IQRF knot from the pad. This eliminated reception of the signal from the unmonitored area (Hartová & Hart, 2017).

Although the use of Bluetooth technology was initially considered, as described in the article on 'Livestock monitoring system using bluetooth technology', it was given up for reasons associated with effectiveness of the detection method (Hartová & Hart, 2017).

As the selected method was proven an optimal solution, just fine-tune a few details and verify in real terms for a long time., since as claimed by the authors of the article 'Livestock Low Power Monitoring System', the development of systems to monitor livestock theft is a necessity today (Lopes & Carvalho, 2016; Hartová & Hart, 2017). Long-term testing will run from 2018 to 2020.

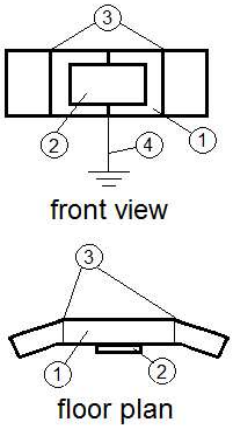

Figure 3. Scheme of shielding pad (1 – shielded pad; 2 – space for placement of the IQRF unit; 3 – shielding flaps with adjustable angle; 4 – electrical grounding).

CONCLUSIONS

Testing and improvement of existing technologies is very important. Due to the continuous development in the field of livestock technology is always important to continue to develop new and better systems.

The originally proposed system for livestock theft monitoring has been only partially successful so far. Outdoor detection almost did not work. Currently has been achieved on the system modification to achieve monitoring of an exactly defined area without its spill-over to undesirable areas.

The centralized method was replaced by a perimeter method. Where the receivers were placed on the perimeter of the guarded area. Additionally, it had to develop shielded pad to limit the reception of signals from the unsecured area.

Wireless transmissions are unfortunately very susceptible to interference – both interference caused by the environment, and interference caused by a targeted jammer. It is important to have an overview of the reliability and functionality of each wireless transmissions. Natural interference which may affect a wireless transmission occurs rather rarely, still it is important for wireless transmissions to be able to either identify such interference or replace the path of transfer. IQRF MESH systems do possess this feature and therefore are more secure in real life operation than standard wireless systems.

ACKNOWLEDGEMENTS. It is a project supported by the CULS IGA TF 'The University Internal Grant Agency' The Examination of the Influence of Blended Biofuels on Operating Parameters of CI Engines, 2017:31150/1312/3116.

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