TESTING OF COMBINED SPACE DETECTORS IN INTRUSION AND HOLD-UP ALARM SYSTEMS

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Abstract. Intrusion and hold-up alarm systems serve primarily for protecting buildings against unlawful conduct of third parties, and can be used as monitoring and control systems. They are therefore primarily a tool for ensuring a state of security. They operate in the material realm (physical protection of property, life and health) and in the emotional realm (providing a feeling of peace, safety and a certain security). As a result it is important for them not to malfunction and for them to be sufficiently resistant to attack. The problem of combined space detectors affects a large proportion of intrusion and hold-up alarm systems (I&HAS). In a time of increasing property crime, it is highly important for combined space detectors to be able to detect movement in space or other penetrations within the guarded area reliably and free of error. In the case of installation of combined space detectors it is naturally important not only to ensure correct installation, to gauge the external influences impacting upon the detector and ensure proper maintenance, but also to guarantee their capability of detection under more arduous conditions (Attempts to sabotage etc.). These tests are important both from an informative perspective and due to the possibilities of development of potential counter-measures, which could lead to their improvement and an enhancement of their level of security. Tests were performed of the sensitivity attenuation in each direction of movement. At the same time, a multicriterial analysis of variants comparing the most common detectors on the Czech market was carried out. In the research, the measured values of the PIR/MW detector and installation convenience were compared. The PIR/MW detector, LC-104-PIMW from the manufacturer DSC, has emerged as being the best choice out of the comparison detectors and ended with 84 % success rate. The other detectors did not fare much worse than the LC-104-PIMW. The second-placed one was the CROW SWAN 1000 detector. In the third position, the RISCO RK415DTDEB. The only detector that does not have such a positive rating is Pyronix-Hikvision KX15DT, which ended with only 63 % success.

Keywords: detector, PIR/MW, testing, security, ergonomy.

Introduction

At a time of increasing property crime, it is very important for detectors to achieve efficiency, reliability, faultlessness, and ergonomic ease of assembly. Combined space detectors are the commonly used space protection elements in alarm systems for intrusion and retention. They can, however, be used in many other applications than simply to provide space protection. Combined space detectors are formed, as the name suggests, two kinds of detectors on another basis of evaluation. They are usually solved with PIR (passive infrared) and MW (microwave) detectors. For proper operation, these detectors are typically DC powered (using a low voltage). The PIR part evaluates movement by a pyro element, which detects a change in temperature with a pyroelectric effect in the background of the space that is under surveillance. The MW part evaluates movement by a Doppler effect, which detects a change reflected electromagnetic radiation and this is a part active, because it emits MW radiation. In the case of installing combined space detectors, it is, of course, not only important to ensure proper installation, to measure external influences on the detector and to ensure proper maintenance, but also to ensure their detection capability in more demanding conditions [1-4].

Combined space detectors are highly prone to poor installation and, as a result, it is very important to pay attention to these detectors. Combined space detectors have in general to reduce number of false alarms and the most common error rate is due mainly to incorrect installation. This is why we have defined a problem, which should serve to compare the properties and parameters of the combined space detector with its suitability for installation [2; 4-6].

Materials and methods

For testing and comparison, digital Combined space detectors PIR/MW were selected (see Fig. 1). These were detectors from DSC, CROW, RISCO, and Pyronix-Hikvision. Detectors with the largest representation in the Czech Republic were selected. These detectors have met Security Level 2 standards (a low-to-medium risk). From each type of detector, five samples were tested and average values of all of the measured results were reported.

Fig. 1. **PIR/MW detectors** (from the left: DSC/LC-104-PIMW; CROW/SWAN 1000; RISCO/RK415DTDEB; Pyronix-Hikvision/KX15DT)

The following tests were carried out.

- Slow test passage:
  - walking speed – 1.5 km·hour^{-1} (simulating offender movement);
  - distance from the detector – 7 m;
  - 10 cycles.
- Range test (max)
  - walking speed – 5 km·hour^{-1} (standard motion simulation);
  - testing started at the maximum distance indicated by the manufacturer;
  - the measurement is repeated cyclically ten times in succession;
  - after a successful measurement, the distance of the drive was extended by half a metre;
  - the alarm should have occurred at least nine times out of ten attempts. If this did not happen, the test was unsuccessful and the test distance was defined as the maximum distance.
- Detection angle test (max)
  - walking speed – 5 km·hour^{-1} (standard motion simulation)
  - distance from detector – 7 m;
  - PIR sensors were monitored during the passage;
  - the measurement is repeated cyclically ten times in succession;
  - during these cycles, the subject's position and the first "reliable" pulse were monitored;
  - a reliable pulse was defined and these pulses had to occur so that at least 8x of ten cycles otherwise the angle is defined as maximum.
- Sampling Test (max)
  - during the activation of the detector (placing it in its alarm state) its current consumption was measured against the data provided by the manufacturer [7].

The measurement was carried out according to the ČSN EN 50131 methodology. The artificial source of heat was replaced by the human source of heat. The test subject had a weight of 90 kg and a height of 191 cm.

In addition, thirteen independent firms were approached. These companies had all of the selected detectors in their installation portfolio. All of these companies filled out a questionnaire, describing which of these detectors best suited their needs. They were to assign three points to the best of the detectors, two to their second choice, one to their third choice, and zero to the worst detector in their view. Decision making on the installation friendliness of detectors was therefore primarily entrusted to installation experts, who are involved in installing these detectors.

The selection of the most appropriate (compromise) variant was carried out using a multi-criteria analysis. The difference in the price of the PIR/MW detectors being compared is insignificant and therefore has not been counted. The difference between the cheapest and most expensive PIR detectors is only 5 EUR, which is not particularly crucial, when investing in the security feature. For this reason, in the case of these particular detectors, their technical parameters are preferred over their cost. Table 1 shows the value of the judged criteria for individual PIR/MW detectors [4; 8].

Table 1

Average expression of detected PIR/MW detector parameters

Type	Slow passage-triggered alarms	Range (max), m	Detection angle, degrees	Current consumption, mA	Installation friendliness
DSC LC-104-PIMW	45	11	87	19	22
CROW SWAN 1000	48	18	80	20	17
RISCO RK415DTDEB	49	16	94	12	24
Pyronix-Hikvision KX15DT	41	15	80	20	15

The priority of each parameter was expressed by means of weights. Weights were determined according to Table 2. The points assigned to the parameters of each PIR/MW detector, the weights, the overall rating, and the PIR/MW detector variant that was selected as the most appropriate are listed in Table 3 [4].

Table 2

Determination of weights for PIR detectors

Parameters	Scoring	Scales
Slow passage-triggered alarms	6	0.167
Range (max)	10	0.278
Detection angle	9	0.250
Current consumption	4	0.111
Installation friendliness	7	0.194
Total	**36**	**1**

Table 3

Selection of the most suitable PIR/MW detector by multi-criteria analysis

Type	Slow passage-triggered alarms	Range (max), m	Detection angle, degrees	Current consumption, mA	Installation friendliness	Points
DSC	6	9	10	8	8	**8.444**
CROW	8	10	9	9	5	**8,326**
RISCO	9	8	7	6	10	**8.083**
Pyronix	4	7	8	8	4	**6,278**
Scales	**0.167**	**0.278**	**0.250**	**0.111**	**0.194**	

Installation friendliness has a higher weight than ability to properly rise slow passage alarm. This is because this slow motion according to CSN EN 50131 does not have to detect these detectors. Nevertheless, this motion is still being compared, because it is a great asset for detectors.

Results and discussion

Of all four PIR/MW detectors being compared, the DSC LC-104-PIMW detector was selected as the best option, with a total score of 8.444 points. This means that the required criteria satisfied approximately 84 % of the total possible score. The CROW SWAN 1000 detector was placed in second position with 8.326 points (83 %), on the third place was placed RISCO RK415DTDEB with 8.083 points (81 %) and the Pyronix-Hikvision KX15DT detector were placed in the last position, from just 6.278 points (63 %). The final order is shown in Figure 2.

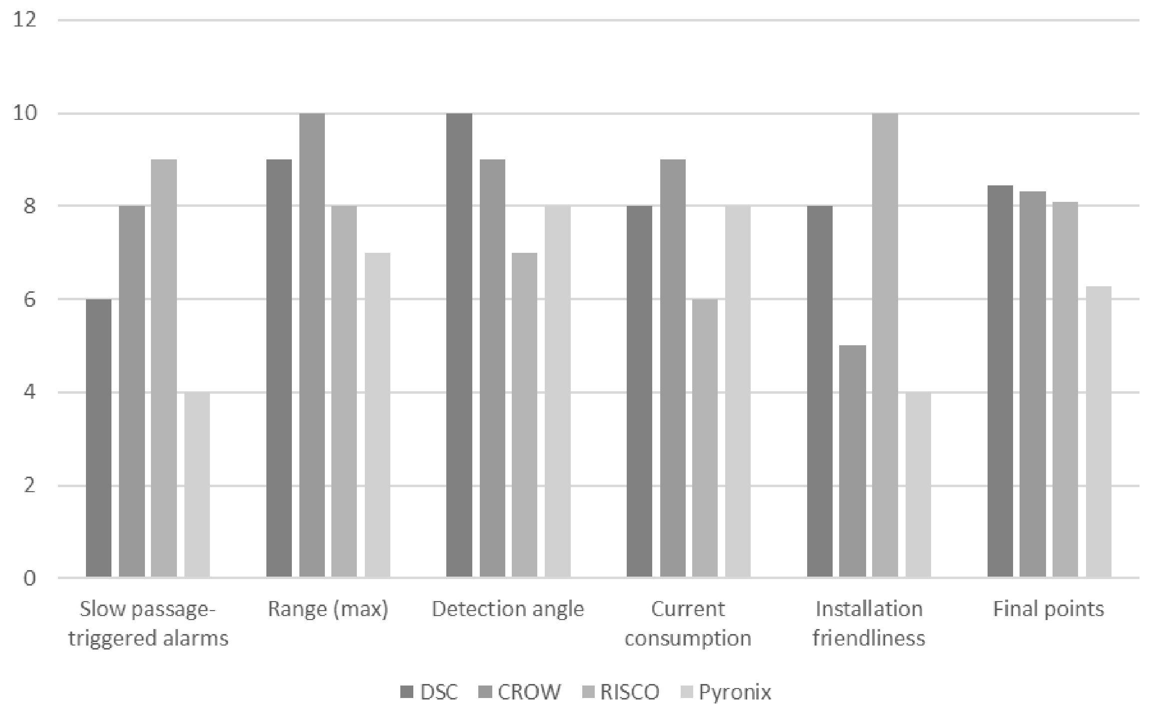

Fig. 2. **Overall standings for PIR/MW detectors**

Until all of the systems have been tested, it is possible only to ask how many detectors and systems are at all secure. A further question is, whether any system exists, which could provide reliable protection for a reasonable price.

Although manufacturers are constantly attempting to develop systems, the majority copy old errors in the technical design into new products of a higher class, even despite the endeavours of customers to ensure manufacture is modified. Without innovative approaches and user feedback, this array will career into a blind alley [4; 5; 8].

This testing is also appropriate, because PIR/MW sensors are beginning to be used to monitor the movement of persons in the smarthome, as reported by the authors in [9].

The issue of detector testing with regard to installation friendliness has not yet been given sufficient attention. For the practical use of detectors, this aspect should be solved more often in the future with different types of detectors.

Conclusions

The technical design of security systems is unique for the majority of manufacturers. In the case of every manufacturer it is possible to find some degree of poor technical design, which requires modification. This deficiency can be resolved through the technical development of the given product and adaptation to customer requirements.

The practical tests, which have been conducted on PIR/MW detectors, delivered a level of insight into their functionality and usability in practice. Using multi-criteria analysis of variants, an optimal PIR/MW detector was selected. In the research, the measured values of the PIR/MW detector and installation convenience were compared. The PIR/MW detector, LC-104-PIMW from the manufacturer DSC, has emerged as being the best choice out of the comparison detectors and ended with a 84 % success rate.

The other detectors did not fare much worse than the LC-104-PIMW. The second-placed one was the CROW SWAN 1000 detector. In the third position, the RISCO RK415DTDEB. The only detector that does not have such a positive rating is Pyronix-Hikvision KX15DT, which ended with only 63 % success.

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