EXPRESS METHOD OF COMPARING THE EFFECTIVENESS OF JAMMERS TO COUNTER REMOTELY ACTIVATED IMPROVISED EXPLOSIVE DEVICES (RAIED)

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ABSTRACT:

Presented is a method of comparing the effectiveness of jammers to counter remotely activated improvised explosive devices **(IED)**. The practical applicability of the method is reasonably justified which allows a fair comparison by using the results of routine laboratory measurements instead of conducting field tests involving significant resource costs - time, organizational, material and financial ones.

KEY WORDS:

IED - IMPROVISED EXPLOSIVE DEVICES;
BJ - BOMB JAMMER;

When the task is one to make a choice between jamming devices used for counterterrorism purposes and offered by different manufacturers, also known as "bomb jammers", one of the main criteria is the effectiveness. In the presented scenario effectiveness means the ability of the jammer to neutralize remotely controlled explosive devices. The greater is the distance of the jamming device which blocks the activation of **IED**, and the wider the frequency range in which it is working, the more effective it is.

The practical question is – which jammer is more effective? This question has a simple answer - the more effective is that jammer with a higher coefficient of protection $\mathbf{K_p}$. Since the coefficient of protection is an integral value, which depends on many factors, then its determination in general is empirical - by conducting a field test. Only after conducting such a test, the user can process the comparing objectively and do follow-on subsequent selection of a particular jammer.

Comparison of effectiveness performed through field test indicates significant involvement of certain resources for the establishment of the organization and conduct of the test itself, such as: human, time and material ones. In addition, the implementation of field test can not be done without consultation with the relevant agencies that control and regulate the use of the electromagnetic spectrum. All in all, the coordination process takes time to implement the legally regulated bureaucratic procedures, and as a result very often the permitted time and place cause too many complications and finally making the field test too expensive to be carried out.

All these concerns mentioned above can be avoided by the application of an express method of comparing the effectiveness using only routine laboratory measurements, and without performing any real emitting interference.

This formalized approach to determine the effectiveness of anti-terrorism jammer to counter **IED** is based on the coefficient of protection - a ratio of the distance around the jammer, whereby the **IED** can not be activated and the distance from the terrorist to **IED**.

The essence of the coefficient of protection is illustrated in **Figure 1 [1]**.

Figure 1.

Using the illustrated figures here are some basic indications to be additionally introduced, such as:

R_p - Distance (radius) of protection;
K_p - Coefficient of protection,

that their interrelationship determine that the coefficient of protection K_p is equal to the ratio of the distance around the jammer, whereby the **IED** can not be activated, and the distance from the terrorist to **IED**, as follows:

$$K_p = R_p / D_{tb}$$

If it is assumed that:

h - coefficient of jamming effectiveness;
n - ratio between jamming and input signal to the receiver of control line, wherein **IED** is not activated;
P_b - power of the transmitter used by terrorist;
P_j - power output of the jammer;
Δf_b - frequency band of the **IED** receiver;
Δf_j - spectrum range of the jammer,

then the coefficient of protection K_p is defined, as shown below:

$$K_p = \sqrt[4]{[\, h * Pj * \Delta fb \,] / [\, n * Pb * \Delta fj \,]}$$

Obviously, the more narrowband is the receiver of the terrorist and the wider is the spectrum range of the jammer, the lower will be the rate of protection *ceteris paribus* – with all other conditions being equal. It is also clear that the increase in the coefficient of protection is associated with improvement of the quality of the jamming „**h**", reduction the ratio between jamming and input signal **"n"** of the receiver of **IED** and naturally - collapse of the spectrum of the jammer **"Δfj"** and increasing its power **"Pj"**.

It is also evident that, in different technical implementations of jammers manufacturers use antennas with different effectiveness, which could lead to considerable differences in pursued coefficient of protection..

The mechanism of the influence of the used antennas is shown in the **Figure. 2**.

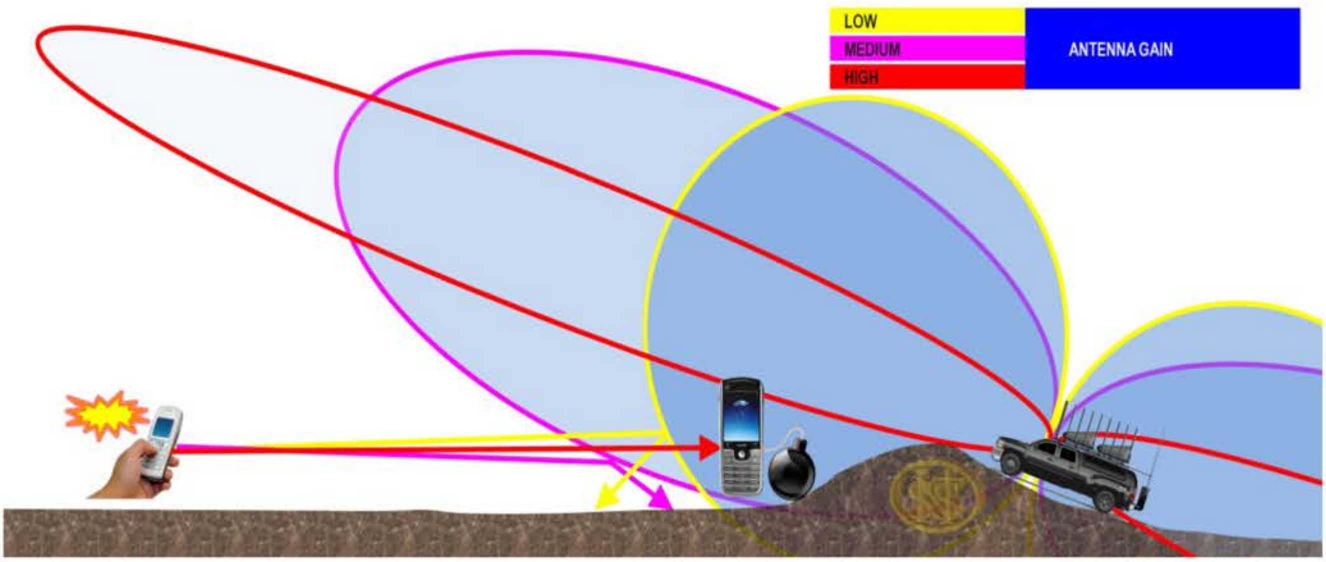

Figure 2.

The use of high-gain antennas (HGA) leads to achieving a significant increase of the Distance of protection and respectively the Coefficient of protection. However, on the other hand such HGA are not suitable for use in complex terrain. To draw a conclusion, in VIP applications when jammer is used in an urban environment, preference should be given to a high-gain antenna. On the contrary, in complex terrain, such as in purely military applications, the antennas are preferably of a lower amplification, i.e. low-gain antennas (LGA).

Antennas with higher gain amplification "focus" the radio wave broadcast in less space, and if **IED** is in that space, the effect is equivalent to increasing the power of the transmitted interfering signal. To take this increase into account, the power output of the jammer „P_j" should be adjusted with the gain of the antenna „A_a".

In practice, the counter measure against **IED** is jamming using noise signals, as the method of Fast Random Scanning **(FRS)** is often used. The quality of jamming **"h"** is the parameter, which depends entirely on the parameters of noise interference (particularly **FRS**), and can be measured for each radio control link specifically designated to **IED**, entirely within laboratory conditions, and without real broadcasting on the air. Also, without real broadcasting on the air could be measured power „P_j" and bandwidth „Δf_j" of the compared jammers.

For the purpose of comparison **"a main"** jammer is selected, i.e. a jammer carrying reserved number #1, as here the parameters are not the measured ones, but predefined ones, as if it is requested during the bidding process. In this case, we are receiving a comparable relative values between the requirements of the applicant and the measured parameters of jammers offered by participating in the procedure manufacturers. In the event that the person making the comparison has obtained data from the manufacturers about the jammers' parameters offered by them, these data could be used directly and the comparison should be made only mathematically. Of course, it should be kept in mind, that all provided manufacturers' data can serve only the purpose of orientation. Reasonable and objective comparison that can be used for decision making can be taken only after the valid laboratory measurements. Measuring the quality of jamming between the main jammer „h_{j1}" and the compared one „h_{jn}", is practically limited to a direct coupling of the receiver of **IED** radio control link, through high frequency summator and standard controllable attenuators corresponding to the output of the jammer and to the output of the transmitter for activation of the **IED**. Device with better quality of jamming is that one that will block the **IED** receiver, with the lower level of its input, at a fixed level signal from the transmitter of **IED** radio control link to the receiver input. A block diagram of interconnections is shown in **Figure.3**.

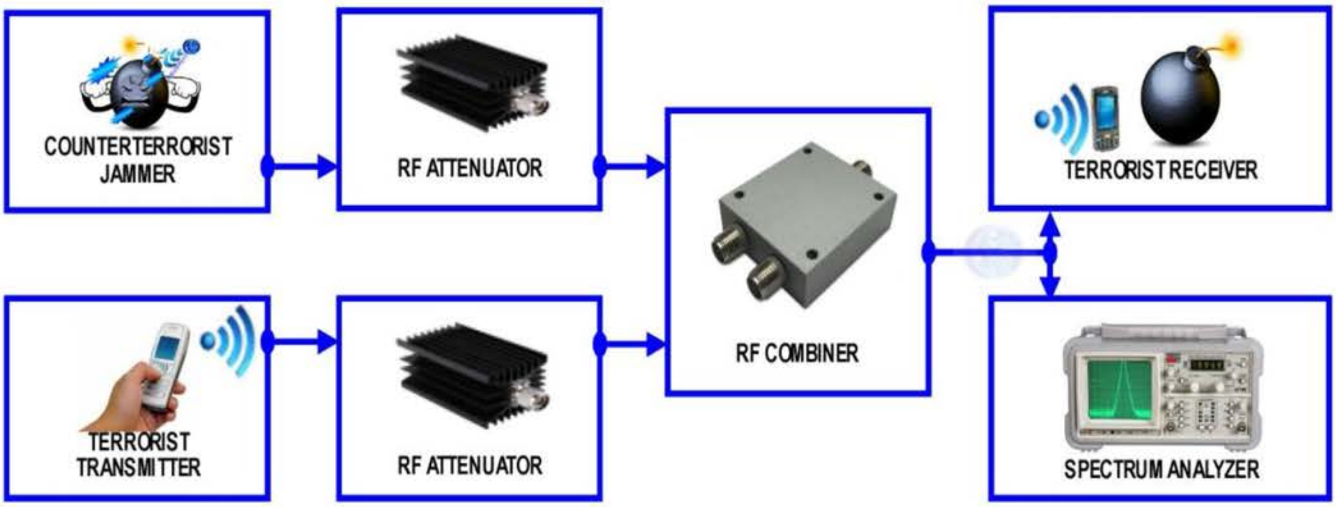

Figure. 3.

The measurement results define the following relationship

$$h_{rat} = h_{j1}/h_{jn}.$$

Defining „h_{rat}", however, do not provide an integral assessment of the effectiveness, but only specify that jammer using interfering signal with better quality. To compare the effectiveness it is sill required to be measured the power output and spectrum width of the evaluated jammers, respectively:

P_{j1}	-	power output of jammer #1;
.... ;		
P_{jn}	-	power of **n-th** compared jammer;
Δf_{j1}	-	spectrum width of jammer #1;
.... ;		
Δf_{jn}	-	spectrum width of **n-th** compared jammer;
A_{a1}	-	antenna gain of jammer #1;
.... ;		
A_{an}	-	antenna gain of **n-th** compared jammer;
$P_{rat1.n} = P_{j1}/P_{jn}$	-	power to power ratio for the compared jammers;
$\Delta f_{rat1.n} = \Delta f_{j1}/\Delta f_{jn}$	-	spectrum to spectrum ratio for the compared jammers;
$A_{rat1.n} = A_{a1}/ A_{an}$	-	gain to gain ratio for the compared jammers.

The ratio of the effectiveness of compared jammers is indicated, as follows:

$$I_{ef} = \sqrt[4]{\Delta frat1.n * Prat1.n * hrat1.n * Arat1.n}$$

Where the effectiveness index I_{ef} has no dimension, corresponding to the ratio of effectiveness of protection against **IED** of the compared jammer to one predefined as “main” jammer, or as requested during the bidding process.

References:

[1] **"Sintis"** concept of jamming Remotely Activated Improvised Explosive Devices **(RAIED)**, **International Conference “SMART DEFENCE SOLUTIONS AND TECHNOLOGIES”,** Bulgaria, Plovdiv, International Fair, 31 May – 1 June 2012, **http://www.hemusbg.org/index.html**, **Defence Institute – MoD, Bulgaria.**

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