Detection of railway signalling jamming signals using the EVM method

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***Abstract*—GSM-Railway is the ground to train radio communication system currently under deployment along the European railway infrastructure. 150.000 km of railway track are foreseen to be covered in Europe in the coming years. The system is designed to ensure different communication services between ground and trains and is replacing progressively various old analogue radio equipment. It is one of the components of the "Euroradio" system, managing voice and signalling data. As a component of a critical infrastructure, GSM-R is a potential target for intentional electromagnetic interference. Indeed, malicious attacks can generate and propagate electromagnetic energy into the GSM-R frequency bands with the objective to impact the whole railway system. This paper presents a methodology based on the error vector magnitude parameter enabling to detect the presence of jamming signals at the receiver. This early detection can then be used by the railway system to appropriately react.**

Keywords-component; GSM-R; EM jammer; Error Vector Magnitude; EM detection.

I. INTRODUCTION

The GSM-R protocol fully complies with the EIRENE railway specifications [1]. Considering the physical layer, GSM-R should provide radio coverage of at least 95% of time on over 95% of the required area. Moreover, the received power by ground or train receivers should be kept in the range -95 dBm to -30 dBm, whatever is the train distance to the nearest ground Base Transceiver Stations. These values, especially the lowest one, indicate that even low-power jammers could possibly interfere with the exchanged railway signalling information.

II. METHOD OVERVIEW AND EXPERIMENTAL RESULTS

Common radio frequency bands are used all over Europe. These allocated frequency bands are 876 MHz to 880 MHz for the uplink, i.e. train to ground communication and 921 MHz to 925 MHz for the downlink, i.e. ground to train. A GMSK standard modulation is used with a normalized bandwidth time product (BT_b) of 0.3. We consider these characteristics to investigate a suitable detection process based on the Error Vector Magnitude (EVM) method. The objective is to quickly detect incoming jamming signals.

A. GSM-R communication chain model

A communication chain is modeled, transmitting GSM-R bursts of 148 bits using a GMSK generator and, superimposing an AWGN noise. We then recover the data using a GMSK demodulator. Disturbances are injected using a wideband CW signal covering a larger frequency band than the allocated GSM-R ones. Signals are extracted and processed.

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B. EVM Detection process

We consider the quadratic specificity of the communication and particularly the EVM parameter. EVM is normally used to evaluate the quality of modulation [2] but, in our study, we use it as an indicator of the presence of jamming signals. The EVM is calculated using the constellation data of both the normal, i.e. non-jammed communication and of the jammed communication as expressed:

$$EVM = |y_i - s_i| \Rightarrow \begin{cases} y_i = \sqrt{I_y{}^2 + Q_y{}^2} \\ s_i = \sqrt{I_s{}^2 + Q_s{}^2} \end{cases} \quad (1)$$

where y_i represents the signal in the normal condition and s_i represents the signal in the jammed condition for I and Q in-phase and quadratic data respectively.

C. Experimental measurement

A GSM-R radio communication is established using laboratory equipment. A communication analyzer is used. On demand, an available hand held jammer is switched on. Fig. 1 represents on the left side the EVM values when no jammer is applied (S/B is set to 20 dB). On the right side, the jammer is applied, 10 dB below the GSM-R received signal level. We conclude than the EVM method detects this specific low-power jamming condition.

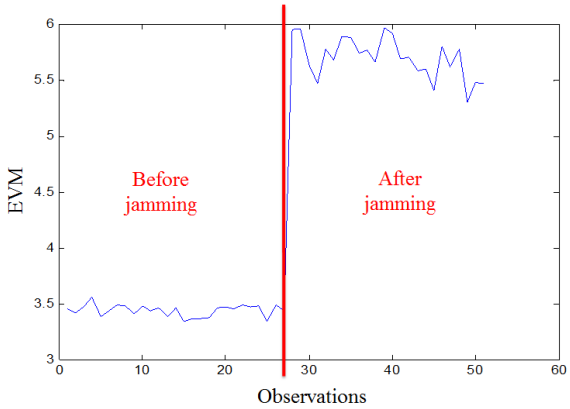

Figure 1. EVM of normal and disturbed conditions.

III. Conclusion

Among the existing detection methods, the EVM method seems a good candidate to implement jamming detection equipment in the receiving chain. This detection information can then be used in order to get a proper system reaction.

REFERENCES

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[2] T.L. Jensen and T. Larsen, "Robust Computation of Error Vector Magnitude for Wireless Standards," IEEE Trans. on Communications, vol. 61, n° 2, pp. 648-657, 2013.