Electromagnetic Compatibility of the Military Handset with Hidden Authorization Function Based on MIL-STD-461D Results

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Abstract—In this paper we present algorithm and hardware architecture of the new military communication device dedicated for VHF battlefield radio stations. The results of the compatibility tests carried out for this device according to the norm MIL-STD-461D are also presented together with the figures and comments. Measurements were carried out at the Electromagnetic Compatibility Laboratory, Faculty of Electronics, Military University of Technology. The Laboratory have accreditation given by the Polish Centre for Accreditation for carrying out those military devices measurements. Described results of measurements will be a base for introduction this developed device into the Polish Armed Forces equipment.

1. INTRODUCTION

One of the most important security problems unsolved till this time in the communications links is voice authorization of the telephone or radio subscriber. Problem is more obvious when it is considered both current voice communications over digital and analog channels: VoIP, PSTN, GSM and state-of-the-art real-time, artificial, speech synthesis in the context of potential risk of impersonating, known in information technology as spoofing. Presented algorithm and hardware architecture are the proposals for increasing security level in unprotected voice calls, as a response to a new telephone attacks named “voice spoofing”.

At present, subscriber’s authorization in telephone calls is performed in the most cases in subjective way using our Human Auditory System. Well known scheme of subjective authorization is based on knowledge of dedicated specific person’s voice. New scheme of the authorization is based on objective way using watermarking (data hiding) technology. Additional binary signature as an inaudible watermark is embedded in the host’s signal voice in the radio or telephone handset and then transmitted over communications links. At the receiving side, using dedicated hardware based on real-time processing algorithm, watermark is extracted and binary signature is compared with the set of binary signatures storage in the handset’s memory. Results of the authorization process is displayed on handset’s LCD. Hardware architecture of the handset is based on the fast, floating-point Digital Signal Processor TMS320C6713 and microcontroller ARM7TDMI family. Handset transmits, watermarked, analog voice, using standard voice interface in the TRC9200 battlefield VHF PR4G radio station family.

![Base scheme of watermark embedder and decoder.](image-url)
2. ALGORITHM AND HARDWARE ARCHITECTURE

Implemented numerical procedures in the Texas Instruments DSP TMS320C6713 floating point processor base on developed algorithm written in Matlab. The basic scheme of the embedder and decoder are shown at Figure 1.

Embedder uses psychoacoustic procedure of computing Minimum Masking Threshold level based on ISO/IEC 11172-3:1993 standard. Host’s speech signal is analyzed in frequency domain to compute all irrelevant and redundant frequency components as well as estimate the Just Noticeable Difference (JND) threshold considered as a smallest difference in a specified modality of sensory input that is detectable by a human being. Watermark (WM) is mapped into OFDM components using B binary signal pattern and then WM signal is shaped, using computed filters’ characteristics, to be inaudible at presence of the host speech signal. In decoder received speech signal frames are segmented and converted to frequency domain. Spectrum is averaged and binary pattern is decoded. Reed-Solomon decoder is used for improving decoding efficiency. Basic scheme of the hardware is shown at Figure 2.

3. RESEARCH METHOD PRINCIPLES

Military electronic devices should fulfill requirements described in the MIL-STD-461D standard concerning, among the others, acceptable radiating and conducting disturbances on the power supply terminals. According to the above recommendations, radiating disturbances for devices or set of devices installed on stationary or mobile objects should not exceed red line plotted values at Figure 4(a)–(c), whereas conducting disturbances on power supply terminals should not exceed the values shown at Figure 4(d). Workstation scheme for measurement of the radiating perturbations emitted by military devices is shown at Figure 3 (left plot). Tested device and receiving antennas arrangement in the unechoic chamber is shown at Figure 3 (right plot).

Measurements of the radiating disturbances emitted by military devices consisted in measurement electromagnetic field strength at the distance 1 metre from tested device using measurement antennas and receiver in the frequency range depending on maximum frequency intentionally generated by tested device. The maximum measurement range is 10 kHz ÷ 18 GHz. Measurements are taken for both vertical and horizontal polarization. Measurement process control is carried out using Rohde&Schrwarz EMC32 control application installed in the control computer. This application computes, among the others parameters, electromagnetic field strength in the measurement antenna place using following formula:

\[ E = U_{in} - T + K \]  

where:
$E$-electromagnetic field in place of the installed measurement antenna in $[\text{dB}(\mu\text{V/m})]$, $U_{\text{in}}$-input signal level in the measurement receiver in $[\text{dB} \mu\text{V}]$, $T$-high frequency line attenuation between measurement antenna and measurement receiver input in $[\text{dB}]$, $K$-correction coefficient of the measurement antenna allowing for antenna effective surface in $[\text{dB}]$.

Measurements of the conducting disturbances on the power supply terminals are carried out in the same way as radiation disturbances with reservation that measurement antennas are replaced by artificial line LISN (Line Impedance Stabilization Network) which serves as the measurement sensor.

Figure 3: Workstation’s block scheme for measurement of the radiating disturbances emitted by military devices (left) and tested device with receiving antenna arrangement in the unechoic chamber (right).

4. TEST BED

The measurement unit named the Equipment Under Test (EUT) consists of developed handset with hidden authorization function, working together with military VHF TRC9200 radio station PR4G family, was tested using MIL-STD-461D recommendation (RE-102, CE-102 specifications). Measurements are carried out using the receivers equipped with peak detectors. Choosing the place for the test bed it should be able to distinguish conducting perturbations inserting by tested device from the outside perturbations background. In this respect, to assess the usefulness of the place, it can be estimated the disturbances background level measured at the presence of the switched off tested device. The level of the disturbances should be at least 6 dB less than acceptable levels shown at Figures 7, 8, 9 and 10.

The recommendation MIL-STD-461D states that receiver should fulfill the requirements concerning the detector type, RBW filter waveband as well as measurement time. In order to do that the ESIB26 receiver produced by Rohde & Schwarz was used. This receiver, according to the producer’s declaration, fulfills all recommendation’s requirements. Artificial line LISN is used for isolation of the tested device from external disturbances occurring in the power supply wires and as a sensor for conducting disturbances detection in the power supply terminals. Measurement procedure is using artificial line ENV216 produced by Rohde & Schwarz. This device has impedance $50 \Omega/(50 \mu\text{H} + 5 \Omega)$. Measured device should be connected to the artificial line from the power supply side, having uncover ending power supply lead wires. The length of the pliant power supply
wire during measurements can not be longer than 2.5 m. All the power supply wires should be taken on 5 cm height above ground or dielectric base. The antennas should be used during measurements as follows:

- at the range of 10 kHz up to 30 MHz it should be used stub antenna having 103 cm height, and placed perpendicularly to antenna counterpoise in the form of square sheet having length side not shorter than 60 cm. Antenna should be equipped in coupler to adjust antenna impedance to the measuring receivers. We used active stub antenna SAS-550-2B type
- at the range 30 ÷ 70 MHz was used biconical antenna SAS 544 type
- at the range 70 ÷ 1000 MHz was used active dipole ADA-3010/A type
- at the range form 1 GHz up to 18 GHz should be used horn antenna. The DRG-118/A antenna type can be used for this purposes. The extended measurement unreliability, estimated for procedures RE-102 and CE-102, equals 3.5 dB and 3.3 dB respectively.

5. MIL-STD-461D RESULTS
The radiating disturbances values (for vertical antennas polarization) were measured using peak detector when radio station had run in the upper frequency range. These values are shown at Figure 4(a)–(c). The results at Figure 4(a) and (b) are not exceeding, recommended by the standard, critical values in all frequency range from 2 MHz 1 GHz considering the extended unreliability of measurements. Critical radiating disturbances values are exceeded using frequency range shown at Figure 4(c). It is the result of the radio station transmission mode on the higher frequencies. These exceeded values are not considered during assessment of conformity with standard recommendation RE-102. The measurement results for conducting disturbances in the range from 10 kHz up to 10 MHz are shown at Figure 4(d). The results are not exceeding, recommended by the standard, critical values considering the extended unreliability of measurements.

![Figure 4: The radiating disturbances values, measured using peak detector, for the ranges: (a) 2 MHz–30 MHz, (b) 30 MHz–70 MHz, (c) 70 MHz–1 GHz and (d) Conducting disturbances values on the power supply terminals for the range 10 kHz–10 MHz.](image)

6. CONCLUSIONS
The measurement test bed is dedicated for assessment of the conformity of tested military devices to the MIL-STD-461D recommendation as well as RE-102 and CE-102 procedures. Tested radio
station unit with handset with hidden authorization function fulfills requirements of the RE-102 and CE-102 procedures. Handset with hidden authorization function was developed and designed in Telecommunications Institute, Electronics Faculty (EF), Military University of Technology (MUT). The measurements were carried out in the Electromagnetic Compatibility Laboratory, EF, MUT.

REFERENCES
4. NO-06-A500, Procedure badań zakłóceń elektromagnetycznych i odporności na narażenia elektromagnetyczne.
5. NO-06-A200, Dopuszczalne poziomy emisji ubocznych i odporność na narażenia elektromagnetyczne.