Application of shielding textiles for increasing safety airborne systems

Limitation of GSM interference

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***Abstract*—Increasing air traffic requires adherence to strict safety rules, including mobile technology interferences. The rules of air traffic define operator duties, e.g. restriction of using electronic devices, which can affect efficiency of board systems and equipments. An operator has to adhere to the rules. Most of airlines solve these duties by verbal or graphical warnings. The article is focused on shielding textiles utilization at special shielding textile case development, which restricts GSM mobile terminals to interfere electronic airborne systems.**

Keywords-textiles, shielding, interference, carbon fiber, carbon textile.

I. INTRODUCTION

An operation of PED (Portable Electronic Devices) on aeronautical boards causes an origination of uncontrolled electromagnetic radiation, which is the interference source of aeronautical systems. PED is divided to several groups according level of dangerousness compared with aeronautical systems [8]. A main group of PDE is transmitters, such as mobile phones. These devices have to be switched off during a flight, especially during lending and taking off [1].

These devices are considered to be transmitters. In our case MS (Mobile Station) transmits user data and control information during communication with GSM network. MS works in frequency range 453 – 1910 MHz. This range depends on transmission technology and the area of presence [9].

Impulse interference can be considered with random characteristic. Practical measurements are realized with continuous power and it transforms impulse interference to continuous interference.

Motivation of considered solution can be the study [2], which is focused on testing of influence of transmit continuous high frequency signal in GSM frequency range to integrated aeronautical board system, which consists from:

- VHF communication transceiver
- VOR/ILS navigation receiver
- Gyro-stabilized telecounting compass

Types and numbers of anomalies are shown in report. Measurement result is motivation to restriction of using MS on aeronautical boards. This restriction also produces a need of accomplishment control to ensure reliable function of airborne avionics. The most serious demonstrations of tested interference are shown in Tab. I. that contains:

- Compass – standard instrument used for azimuth measuring,
- Indicators – states of various aircraft system (lights),
- VOR (VHF Omni–directional Radio Range) – radio navigation system for aircraft,
- ILS (Instrument Landing System) – highly accurate means of navigating to the runway,
- Audio device – communication audio systems.

TABLE I. DEMONSTRATIONS OF TESTED INTERFERENCE [2]

Aircraft system	Defect
Compass	Stiff azimuth, fast changes of azimuth values
Indicators	Unstable data
VOR	5 degree error
VOR	“From” – “To” changes
VOR and ILS	Error data without warnings
ILS Localizer	Less apparatures sensitivity
Audio device	Background noise

Motivation could be other study [10], based on the portable telephones interference measurement.

The remainder of this paper is structured as following. In Section 2 we give a short state of art description and basic approach in Section 3. Based on this summary we present the absorber proposal in Section 4. Next section presents measurement and absorber function validation. Finally, we draw conclusions and future work proposals in Section 6.

II. STATE OF THE ART

Introduced measurement is only one of the many solutions [11]. Their common conclusion is a confirmation of restrictions of using MS in critical parts of the flight [12]. Verbal warnings are used in civil aeronautics, e.g., “Please switch off your mobile phones” [1]. This request is also

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described in instructions for passengers and placed in different parts of aeronautical board interior.

The most critical time interval of whole flight is time before the aircraft takes off (device calibration), during taking off, lending and in the case of nonstandard situation. An attention of the crew can be dispersed by incorrect information of airborne devices in these time intervals. It can further cause wrong reactions of the crew.

A proof of connection aeronautical disaster and PED (Portable Electronic Devices) interference does not exist, but an influence of interference was proofed several times not only in laboratory environment [2].

One of the effective ways of prevention against disaster is shielding cases, which prohibit communication between MS and base stations. Therefore it reduces interferences between MS and airborne avionics or other airborne telecommunication systems.

III. BASIC APPROACHES

A quality is generally defined by SNR (Signal to Noise Ratio) parameter. It expresses a ratio of power levels of useful signal Ps [W] and signal power noise Pn [W] (1).

$$SNR = \log \frac{Ps}{Pn} [dB] \qquad (1)$$

Input circuits of general radio receiver can process receiving signal only for specific minimal SNR to recognize individual signal elements with using modulation method.

SNR reducing (Ps reducing) leads to a growth of BER (Bit Error Rate). A demodulator of receiver radio part generates failures, caused by circuit quantity equivocation in the limits of individual signal elements. Robustness of receiver radio part compared with reducing SNR depends on used modulation method [5]. An example of BER to SNR dependence for different types of modulation methods illustrates Fig. 1.

Reducing SNR and increasing BER by increasing communication distance between base station and mobile terminal is dependence in real situations. Power level of useful signal Ps decreases and power level of noise signal Pn remains the same. It is caused by attenuation of transmission channel, which is in our case realized by free space. L_{PATCH} is generally defined by attenuation of electromagnetic wave with certain wave length (λ) and at distance (d) propagated in free space (wireless data transmission) [6].

$$L_{PATCH} = \left(\frac{\lambda}{4 \cdot \pi \cdot d} \right)^2 [dB] \qquad (2)$$

If the goal is to restrict communication between base station and mobile terminal, it is necessary to increase attenuation of transmission channel with the aid of additional losses. This modification leads to SNR reducing and BER increasing, i.e. disconnecting of mobile terminal from its network.

New attenuation is L^*_{PATCH} and it adds to the L_{PATCH} additional obstruction $SE_{ABSORBER}$.

$$L^*_{PATCH} = \left(\frac{\lambda}{4 \cdot \pi \cdot d} \right)^2 + SE_{ABSORBER} [dB] \qquad (3)$$

Undesirable electromagnetic signals are attenuated by electromagnetic shielding or absorber of electromagnetic field in EMC (Electromagnetic compatibility) branch.

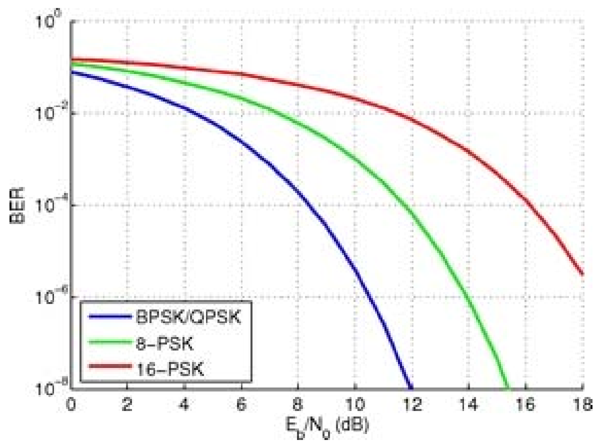

Figure 1. BER depending on SNR for 3 types of modulation methods [5].

Electromagnetic shielding effectiveness is a parameter, which describes an ability of specific material to limit a penetration of high frequency signal over certain barrier.

Shielding ability, i.e. reduction of intensity of electromagnetic field, is based on originating reflections of electromagnetic wave and its absorption in specific material. A heating is generated during absorption of high frequency energy like a product of transformation electromagnetic field energy to thermal energy. Shielding principle is shown on Fig. 2.

A part of the incident electromagnetic wave is reflected from the barrier (Reflection). The other part of incident energy is attenuated by reflections inside the barrier (Re-reflection) and the last part of the energy is transmitted through barrier (Transmission) [3]. The shielding effectiveness is possible to be described by following formula (4) [4].

$$SE = R + A + B [dB] \qquad (4)$$

where R is Single/reflection loss, A is Absorption through the shield and B is multiple/reflection coefficient.

Values of specific parameters, which correspond to a specific material and a construction of used barrier, have an effect to resulting value of ESE. The ESE describes a difference between intensities of electromagnetic field, which limp and pass through the barrier. As a consequence it is possible to express ESE by logarithm of quotient intensities of electric or magnetic component of electromagnetic wave or also by power levels (5).

$$ESE = 20 \cdot \log \cdot \left| \frac{E_i}{E_t} \right| = 20 \cdot \log \cdot \left| \frac{H_i}{H_t} \right| = P_i - P_t \, [dB] \quad (5)$$

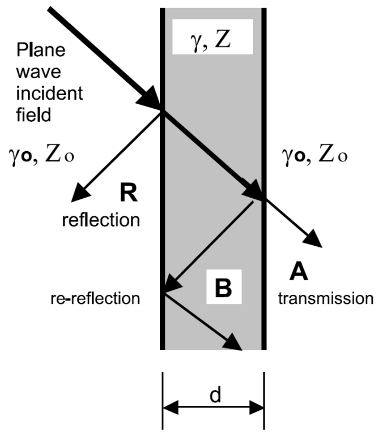

Figure 2. Shielding principle [4].

IV. PROPOSAL

An ability of specific material to attenuate intensity of electromagnetic field relates to its electric conductivity [3], [4]. One of the most advanced methods of construction textile planar materials, with electric conductivity, is a usage of carbon continuous yarn [13], which is used as a substitute of glass fibers in production of laminated products.

An absorber is formed by composite lay-out of three layers of planar textile materials. External and internal surface is formed by utility textile based on polyester. A core contains specially developed textile with shielding effect against electromagnetic wave in frequency range tens MHz – units GHz [14]. This textile is a result of research and development activity of Be-Tex project [15].

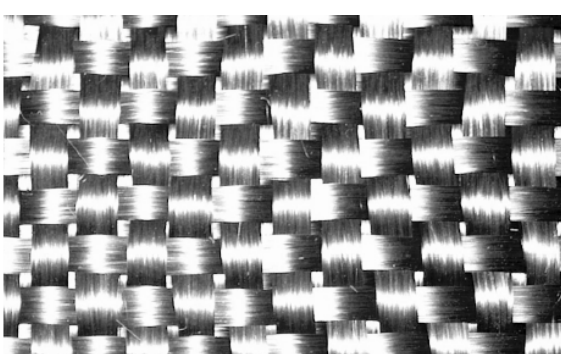

Figure 3. Macro picture of carbon textile.

Samples of used materials were produced in cloth structure, weft and warp end contain only composite carbon yarn with rectangular section (1 x 0,3 mm) and finesse 220 Tex. Count of cloth is 10 thread to one cm. Macro picture of used carbon textile is shown in Fig. 3.

Physical and mechanical parameters (e.g. attenuation in frequency range) of this new shielding textile can be changed by production parameters (finesse, count of cloth in weft and warp, carbon yearn density).

A model set of absorber and MS is shown in Fig. 4 and Fig. 5.

Figure 4. A model set of absorber and MS.

Figure 5. A model set of absorber and MS.

V. MEASUREMENT AND VALIDATION

It is necessary to place a measured object into a case, which is made of tested material – shielding textile, for attenuation measurement. A value of attenuation is obtained by comparison of difference between intensity inside and outside the case.

It is possible to use EMC measuring boxes for testing mobile terminals EMC for this type of measurement. As a result of this measurement it is only an attenuation value of measured object in near or far field. A confirmation of designed prototype system of hardware protection operation requires measurement with specific mobile terminal type.

NOKIA mobile phone can be used for the measurement by reason of easy accessibility of measuring engineering. The mobile phone NOKIA 3310 with activated service menu is a good option. It enables direct reading of signal level values measured in dBm. Measurement is preformed outside the case and then inside the case. Difference and averaging is used for calculation of attenuation value of measured case.

Measuring software is used for the calculation. Software communicates with MS via RSS232 interface and logs measured data. Measuring results are shown in graphs in Fig. 6 and Fig. 7 for GSM frequency range 900 MHz and 1800 MHz.

The BTS SCAN v 2.00 software is used. It is the freeware software of GSMCables company [7]. Accuracy of measurement of GSM signal power level for specific GSM radio channel is +/- 0.5 dB. The software is only an instrument for remote communication and control of GSM mobile phone service menu via AT commands.

The result of realized experiment and developed textile absorber is a functional sample, which restricts MS-base station communication. This textile material has attenuation 38 dB in frequency range 900 MHz and 30 dB in frequency range 1800 MHz.

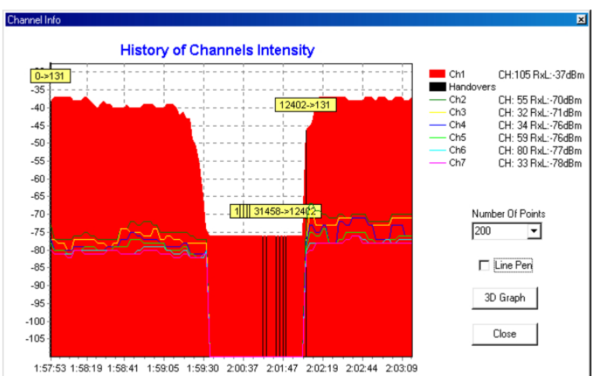

Figure 6. Attenuation of GSM signal in frequency range 900 MHz, mobile phone is placed inside the case.

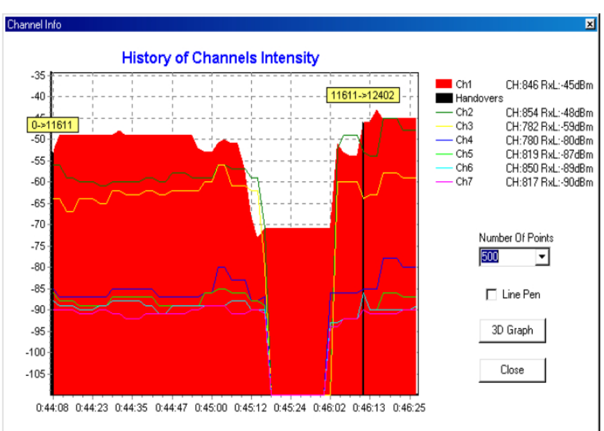

Figure 7. Attenuation of GSM signal in frequency range 1800 MHz, mobile phone is placed inside the case.

VI. Conclusion and Future Work

Future work is focused on shielding textile structure optimization with a goal to increase attenuation values of this textile for high frequency range. Current attenuation does not have to be sufficient for some applications. Therefore it is necessary to increase attenuation values.

This paper describes development of textile absorber for MS-base station communication restriction, which restricts from impulse interference causing errors of airborne avionics and other telecommunication systems on boards. The fulfilled goal is a restriction of MS to influence other sensitive devices. Developed absorber has attenuation 37 dB in frequency range 900 MHz and 30 dB in frequency range 1800 MHz. Experiments showed these attenuation values fulfill required features – mobile phone is not able to communicate with base station in GSM network.

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