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ГІБРИДНІ ТЕХНОЛОГІЇ ДЛЯ РЕАЛІЗАЦІЇ РАДІОСИСТЕМ МІЛІМЕТРОВОГО ТА ТЕРАГЕРЦОВОГО ДІАПАЗОНІВ

Розглянуто технології, що будуються на поєднанні різних властивостей і переваг радіо- та оптичних систем, які пропонуються для реалізації телекомунікаційних систем зв'язку в міліметровому і терагерцовому діапазонах. Показано, що використання гібридних топологій мережі, оптоелектронних методів формування і обробки сигналів, формування діаграм спрямованості антен, а також застосування компенсуючих методів може підвищити спектральну і енергетичну ефективність перспективних систем зв'язку в діапазонах 75...110; 200...450 ГГц.

Ключові слова: міліметровий діапазон; терагерцовий діапазон; гібридні технології; оптоелектронні методи обробки радіосигналів; фотоніка; спектральна ефективність; енергоефективність; radio-over-fiber.

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ГИБРИДНЫЕ ТЕХНОЛОГИИ ДЛЯ РЕАЛИЗАЦИИ РАДИОСИСТЕМ МИЛЛИМЕТРОВОГО И ТЕРАГЕРЦОВОГО ДИАПАЗОНОВ

Рассмотрены гибридные технологии, основанные на сочетании различных свойств и преимуществ радио- и оптических систем, предлагаемых для реализации телекоммуникационных систем связи в миллиметровом и терагерцововом диапазонах. Показано, что использование гибридных топологий сети, оптоэлектронных методов формирования и обработки сигналов, формирования диаграмм направленности антенн, а также применение компенсирующих методов — все это может повысить спектральную и энергетическую эффективности перспективных систем связи в диапазонах 75...110; 200...450 ГГц.

Ключевые слова: миллиметровый диапазон; терагерцовый диапазон; гибридные технологии; оптоэлектронные методы обработки радиосигналов; фотоника; спектральная эффективность; энергоэффективность; radio-over-fiber.

УДК 517.9:621.325.5:621.382.049.77

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PRELIMINARY TESTS THERAHERTZ 3D IMAGING RADAR

Were conducted preliminary tests terahertz 3D imaging radar for different system configurations and studied the properties of materials depending on the distance between the sample and the antenna.

Keywords: absorber; digital spectral analysis; electromagnetic simulator; horn antenna; far field and near field pattern.

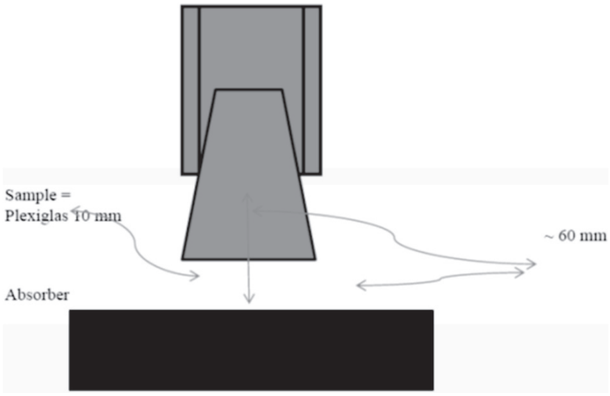

Fig. 1. Used conical horn antenna

INTRODUCTION

In scientific laboratories SPE «Quantor» designed and manufactured **FMCW** (*Frequency Modulation Continuous Wave*) radar with the following parameters: frequency band linear; frequency modulation — from 92 to 96 GHz; period (length of interval) — 1 ms; bit ADC — 16 to 32 bits; the number of cycles of accumulation — from 1 to 10 000; layers reflection — 3; distance to layers reflection — 0.095; 0.105, 0.106; wave propagation environment — air; signal-to-noise ratio — from 80 to 30 dB.

We used conical horn antenna (fig. 1). The main characteristics of the various methods of spectral estimation parameters of signals were tested in order to study radar system.

In order to study the main characteristics of the various methods of spectral estimation parameters signals of field was built a test model of determinate harmonic signal [1].

To study the characteristics of the methods of spectral estimation of signal parameters was established deterministic model test harmonic [2].

There is obtained equation model of the non-liner method. Experimentally confirmed valuation parameters signal FMCW radar with different noise levels and different distance to horn [3].

MAIN PART

Description of the system 3D head problem

Fig. 2 displayed our configuration: 3D head looks at the flat metal plane. So, the emission beam is totally reflected from the metal surface and then it returns back to the horn.

Fig. 2. Measurement set up

When the head was functioning the measurement result was like in the fig. 3.

In the same measurement configuration, we don't have any results in the absence of direct visibility. As shown in the fig. 4 we see only a flat trace.

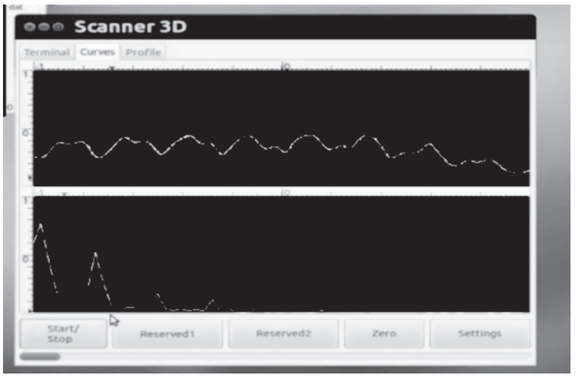

Fig. 3. Result when the head is working properly

Fig. 4. The head isn't working properly

When the 3D Head is switched off for a long time (undefined, but of a few days), the device returns to work again properly for a indefinite time.

We built a new system to do measurements with the head 3D [4]. It is shown in the fig. 5 and 6.

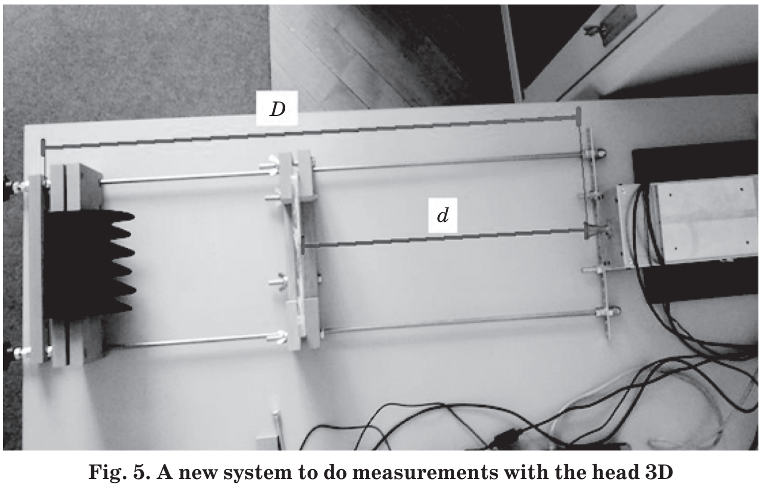

Fig. 5. A new system to do measurements with the head 3D

Fig. 6. New system head 3D

The horn is at 80 cm from the absorber and the sample holder that we use to put the samples to test can be moved along the length between the horn and the absorber. The absorber is with height 10 cm as showed in fig. 7.

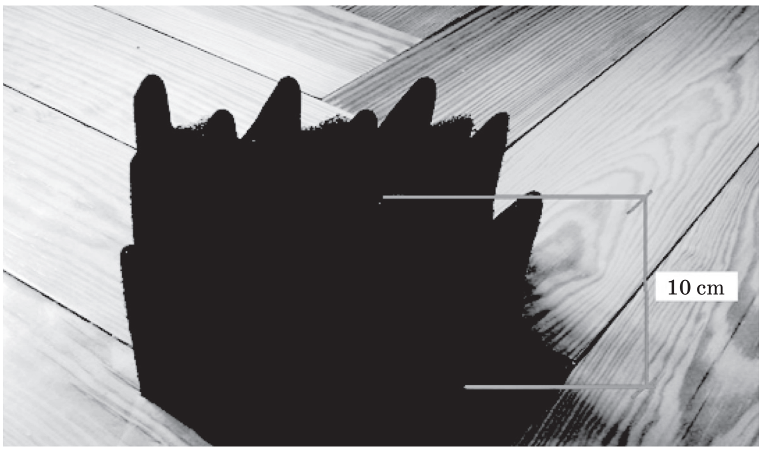

Fig. 7. Small piece of absorber

We need to do 3 kinds of test. Our start set up (see fig. 6) and it is characterized by the following parameters:

$$D = 80 \text{ cm}; \ d = D/2 = 40 \text{ cm}.$$

This set up is the start set up in all tests.

In this condition:

1) we measure the signal without the sample (5 times) noting data_out_0... data_out_4;

2) we place the sample (plexiglas of 10 mm) on the absorber and we repeat the measure 5 times noting data_out_5...data_out_9;

3) on the top of the sample we stick a thin conducting film (carbon fiber of 0.4 mm) and we repeat the measure 5 times noting data_out_10... data_out_14;

4) we flip back the sample with the film conducting and we measure 5 times noting data_out_15...data_out_19;

5) in all test we make a point of 50 measurements. We mean that there are 50 measurements in every data out.

Result of the tested using the programm «Scan processing»

We make 3 different tests:

a) using only one material at different distances from the horn;

b) using two layers of the same material placed at different distances from each other;

c) using two layers of different material placed at different distances from each other.

Case 1

In the first kind of tests, we distinguish 3 different results using different materials.

In the case of layer of about 1 cm in plexiglass we see that the measurement in frequency changes from time to time.

For example: plexiglass on the worktop at 35 cm from the horn (fig. 8).

Fig. 8. Plexiglass on the worktop at 35 cm from the horn

Sometimes we see 7.133, other times 7.122, etc. Moreover, we expect to see one peak at frequency 7 (in according to the conversion factor 50.0 we must have 35 cm = 50.0 + 7). If we put the layer closer to the horn the measurement accuracy decreases. In the images the case of plexiglass at 10 cm from the horn (fig. 9).

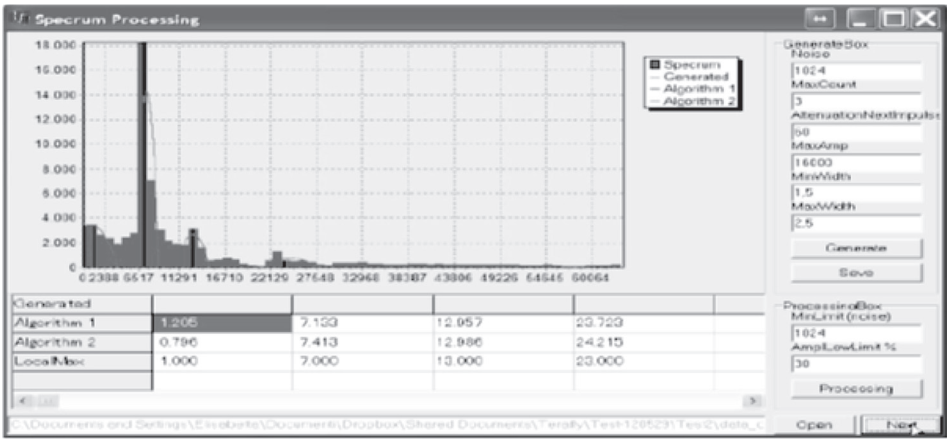

Fig. 9. Plexiglass on the worktop at 10 cm from the horn

We expected to see one peak at frequency 2.0 instead we see 2.724, 2.754 (fig. 10 and 11) and so on.

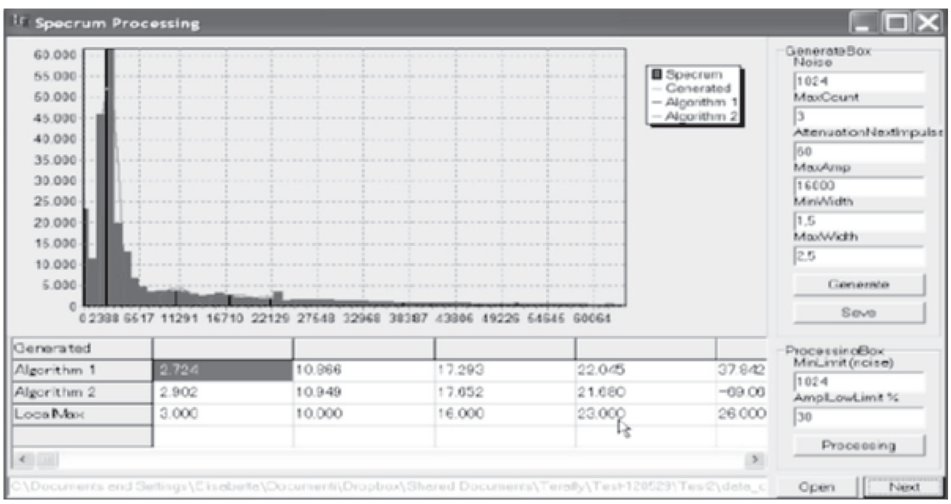

Fig. 10. Composite material in kevlar

In the case of thin layers (less than 1 cm) of composite material in kevlar (see fig. 10) we saw that the measurement in frequency is always the same and centered at the frequency of 7.000 (over 90 Ghz) for layer at 35 cm from the horn. Also in this case we see the other peaks. For example in the frequency 2.393 and 12.745 (fig. 11 and 12).

In the case of layer in plastic 1 cm thick, we see that the measurement in frequency is always the same and centered at the frequency of 7.000 (90 GHz) (fig. 14) and 12775 (over 90 GHz).

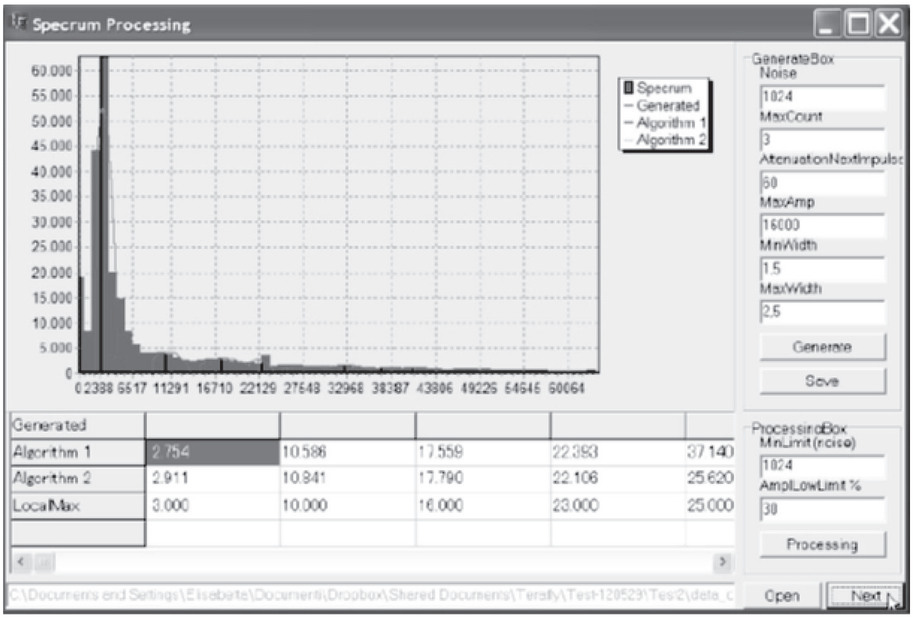

Fig. 11. Composite material in kevlar for the frequency 2.393 (90 GHz)

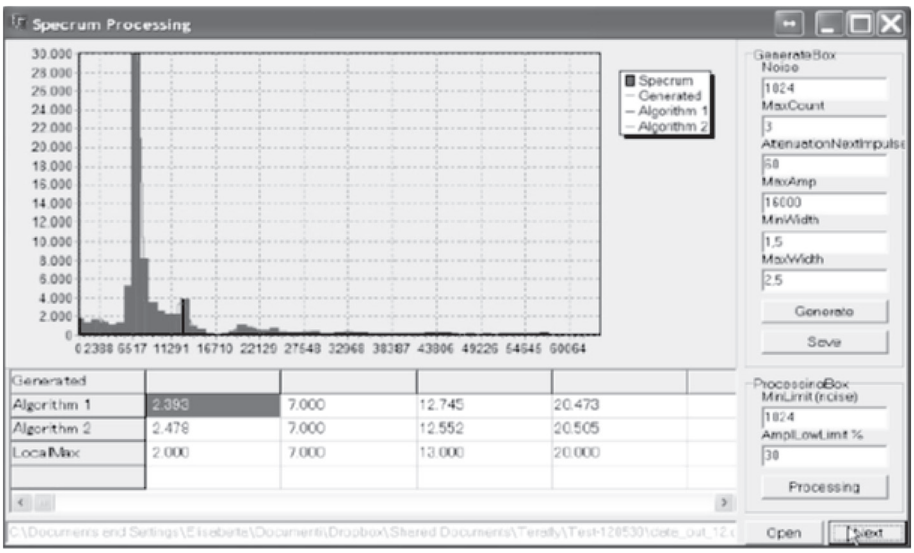

Fig. 12. Composite material in kevlar for the frequency 12.745 (over 90 GHz)

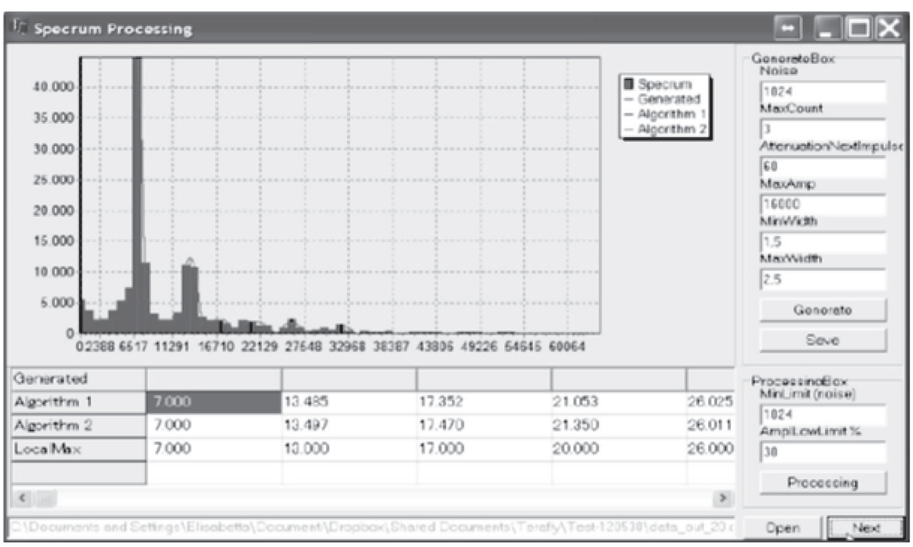

Fig. 13. Plastic on the worktop at 10 cm from the horn for the frequency 7. 000 (90 GHz)

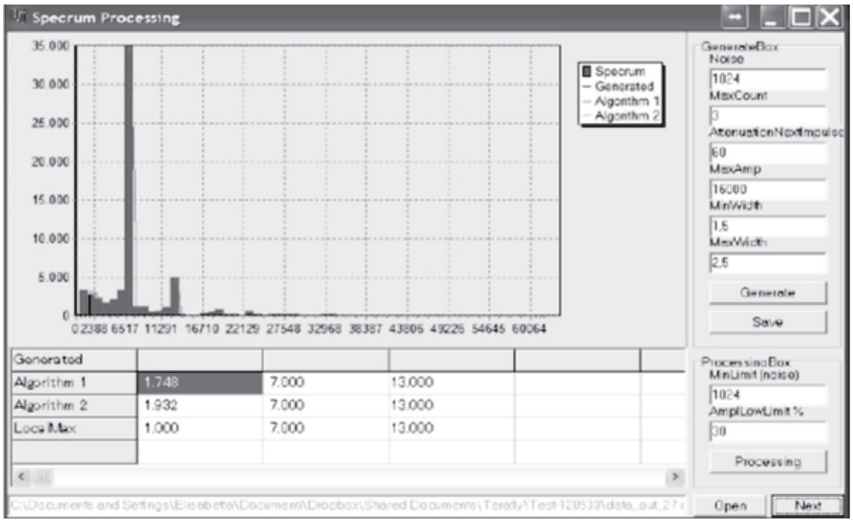

Fig. 14. Plastic on the worktop at 10 cm from the horn for the frequency 12.745 (over 90 GHz)

<u>Case 2</u>

In the second kind of tests we used two layers of the same material placed at different distances from each other. In this case we can not correctly measure their positions. For example 2 layer at 15 cm (fig. 15). We expect to see two peaks at frequency 4.0 (20 cm from the horn) and 7.0 (35 cm from the horn) respectively. We have some uncertainly.

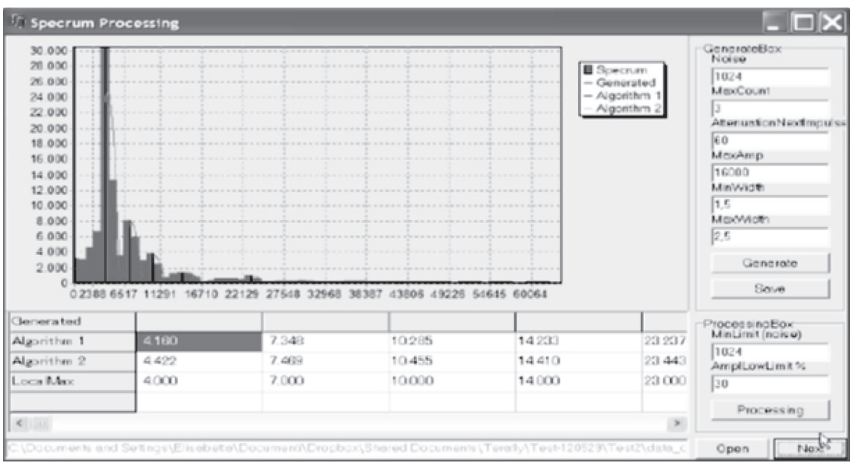

Fig. 15. 2 layer at 10 cm on the worktop at 15 cm from the horn

However we never distinguish them if they are far less than 10 cm from each other.

For example 2 layer at 10 cm (fig. 16).

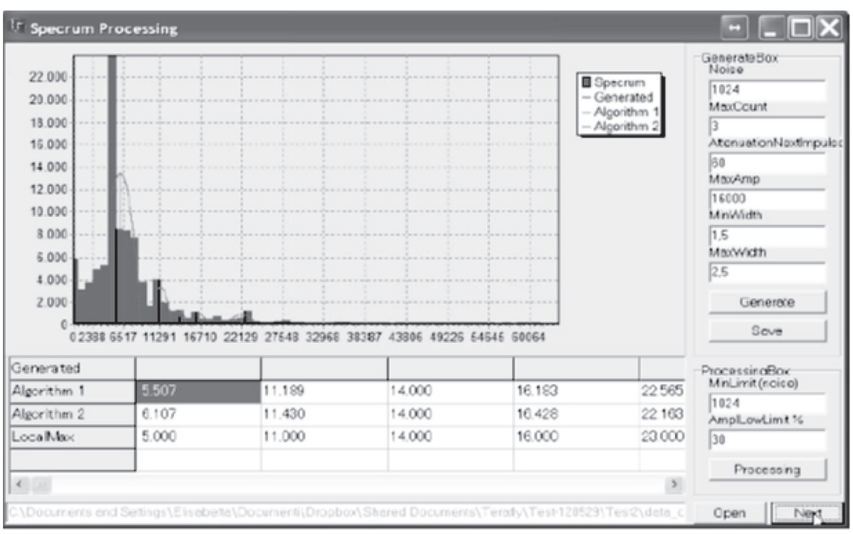

Fig. 16. 2 layer at 10 cm on the worktop at 10 cm from the horn

Case 3

In the third kind of tests we used two layers of different material placed at different distances from each other. In the following image we have one layer in kevlar at 35 cm and one layer in plexiglass at 25 cm from the horn respectively (fig. 17).

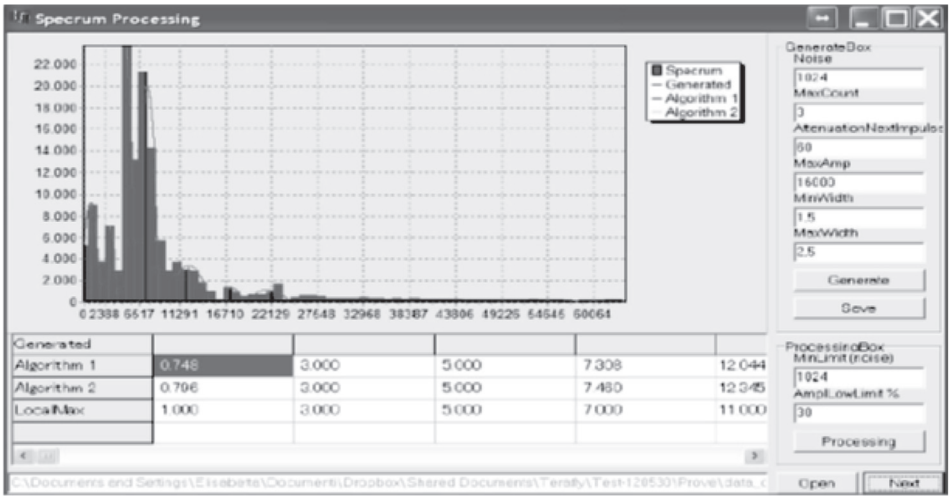

Fig. 17. One layer in kevlar at 35 cm and one layer in plexiglass at 25 cm

Protocol of test to perfom measurements

The measurements will be made as following.

Test 1

In the test 1 the measurements are made on a single material at a time. The materials are plexiglas and layer of kevlar/diolene. We will do measurements using before plexiglas and then one layer of kevlar/diolene. The thickness is not important.

The procedure is as follows:

1) we put the system in the condition of start set up. This means that at the bottom is present the absorber (D = 80 cm) and the sample is put at d = 40 cm. This is the first measurement;

2) then we move the sample by increasing the distance from the horn of 1 mm at a time. We repeat this 10 times. After each movement we record the spectrum. So the measurements correspond at these distances from the horn: 401; 402 and so on until 410 mm;

3) from this position (41 cm), we move the sample by increasing the distance from the horn of 1 cm at a time. For each position we record the spectrum. We repeat this 10 times. So the measurements correspond at the distances from the horn: 42; 43; 44 and so on until 50 cm;

4) we repeat paragraphs 1-3 for both materials.

Test 2

In the test 2 the measurements are made using the same samples (plexiglas and layer kevlar/diolene). We will do measurements using before plexiglas and then one layer of kevlar/diolene. The sample is kept in stop at d = 40 cm and the absorber is made move from the back of the sample to the bottom of the system (D = 80 cm).

1. The sample is at the distance d = 40 cm. Behind it and adherent its surface, is put the absorber. We record the spectrum.

2. From this position (40 cm), we move the absorber by increasing the distance from the sample of 1 cm at a time. For each position we record the spectrum. We repeat these different times. These measurements are necessary to understand if and how the absorber influences the measurements.

Test 3

Now we use two plates and make the «sandwich» (fig. 18). The first one (in front the horn) must be homogeneous and weakly absorbing (we use plexiglas). The second one is behind and adherent the first.

We repeat the same steps of the test 1 with this sample (fig. 19).

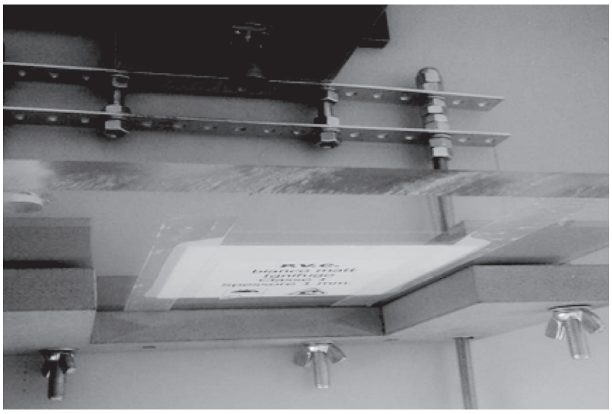

Fig. 18. Using two plates and make the «sandwich»

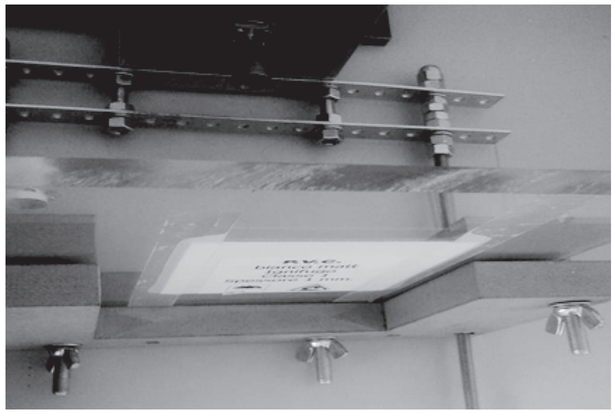

Fig. 19. Sample like «sadwich»

CONCLUSION

We measure the signal without the sample (5 times) noting data_out_0... data_out_4. Later we placed the sample (plexiglas of 10 mm) on the absorber and we repeat the measure 5 times noting data_out_5... data_out_9.

On the top of the sample we stuck a thin conducting film (carbon fiber of 0.4 mm) and we repeated the measure 5 times noting data_out_10... data_out_14. Later we flipped back the sample with the film conducting and we measured 5 times noting data_out_15...data_out_19.

In all test we made a point of 50 measurements. We mean that there are 50 measurements in every data out.

Then we made tests. In the test 1 the measurements are made on a single material at a time. The materials are plexiglas and layer of kevlar/diolene (see fig. 19). We do measurements using before plexiglas and then one layer of kevlar/diolene. The thickness is not important.

In the test 2 the measurements are made using the same samples (plexiglas and layer kevlar/diolene). We do measurements using before plexiglas and then one layer of kevlar/diolene. The sample is kept in stop at $d = 40$ cm and the absorber is made move from the back of the sample to the bottom of the system ($D = 80$ cm). Then we used two plates and make the «sandwich». The first one (in front the horn) must be homogeneous and weakly absorbing (we used plexiglas). The second one is behind and adherent the first.

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М. А. Косовець

ПОПЕРЕДНЄ ТЕСТУВАННЯ 3D ТЕРАГЕРЦОВОГО РАДАРА ЗОБРАЖЕННЯ

Описано низку попередніх тестів, проведених для встановлення залежності властивостей матеріалу, з якого виготовлено зразок, від впливу далекого чи близького поля антени для різних конфігурацій радарної системи.

Ключові слова: поглинач; цифровий спектральний аналіз; електромагнітний імітатор; рупорна антена; модель далекого і близького поля.

Н. А. Косовец

ПРЕДВАРИТЕЛЬНОЕ ТЕСТИРОВАНИЕ 3D ТЕРАГЕРЦОВОГО РАДАРА ИЗОБРАЖЕНИЯ

Описан ряд предварительных тестов, проведенных для установления зависимости свойств материала, из которого изготовлен образец, от влияния далекого или близкого поля антенны для различных конфигураций радарной системы.

Ключевые слова: поглотитель; цифровой спектральный анализ; электромагнитный имитатор; рупорная антенна; модель далекого и близкого поля.