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The New Method of the Microstrip Antennas Diagnosing

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Abstract

Microstrip antennas have been since more than ten years one of the most innovative areas of antenna technology. As the novelty in article, one of possible diagnostic methods of microstrip antennas is presented, which is based on using thermography. Within the method proposed a distribution of temperatures recorded by the thermovision camera on the microstrip antenna surface is used for its diagnostics. The above diagnostics is based on verification of antenna parameters (SWR) influencing local changes of the temperature distribution on the antenna surface. The proposed methodology of antennas diagnostics was discussed basing on the example of three models of microstrip antennas.

1. Introduction

A serious disadvantage of a microstrip antenna is the limited power load capacity. This last feature can be a cause of its damage when applying too high power to it. The above limitations can be the cause of serious failures during tests of prototypes as well as in the period of microstrip antennas operation.

One of the critical elements of the microstrip antenna having considerable effect to the power losses, and therefore also to the temperature distribution on the surface of the antenna, is the feeding system of the antenna. Considerable heating of the radiator in relation to other components of the antenna is a symptom of the impedance mismatching, because the power will mainly be dissipated by this element. In the case of mismatching the input impedance of the antenna a part of the power will be reflected from the input terminals and return to the transmitter. When it arrives to the transmitter it will be reflected for the next time and again come back to the antenna. A higher temperature in the surroundings of input terminals of the antenna can be expected with these working conditions.

Therefore, the suitable diagnostics is the essential element in the tests process of prototypes as well as operation of such type antennas.

Here, in this article, one of possible diagnostic methods of microstrip antennas is presented, which is based on using thermography [1]. Within the method proposed a distribution of temperatures recorded by the thermo vision camera on the microstrip antenna surface is used for its diagnostics. The above diagnostics is based on verification of antenna parameters influencing local changes of the temperature distribution on the antenna surface. The proposed methodology of antennas diagnostics was discussed basing on the example of three models of microstrip antennas.

2. Models of Microstrip Antennas

In order to investigate the temperature distribution on the surface of microstrip antenna as well as verify its relation to the standing wave ratio SWR at the antenna input the three models of microstrip antennas were designed and made [2-5], intended for operating in the frequency band from 2 GHz to 3 GHz. The antennas designed are:

- single element antenna,
- two element antenna,
- four element antenna.

The mentioned above models of antennas were done in the electromagnetic coupling technology. The view of the antennas models done is presented in the Fig. 1.

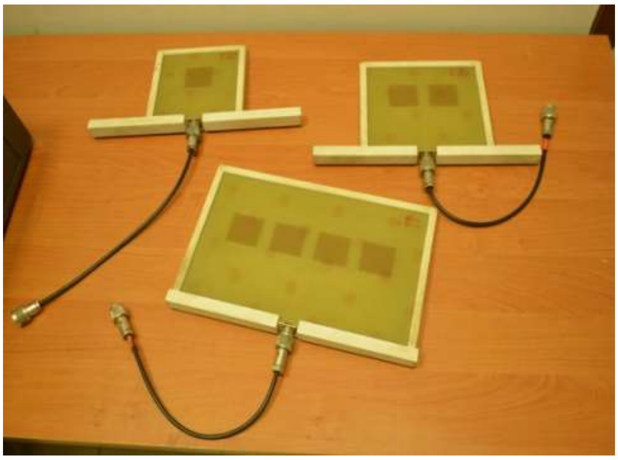
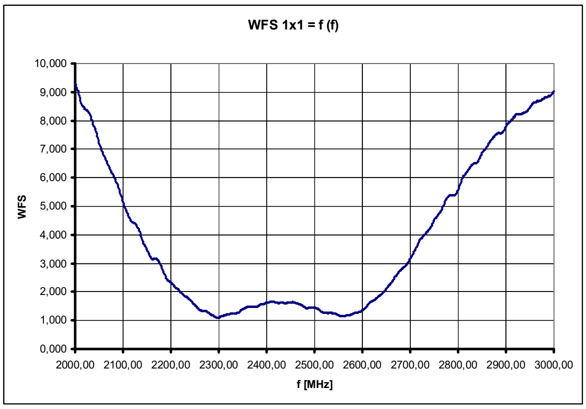


Figure 1. Microstrip antennas models designed.

In order to compare the temperature distribution on the surface of microstrip antennas models made with the value of the standing wave ratio SWR that has an essential effect onto power losses, and therefore also onto the temperature distribution, in particular near the antenna connector, measurements of SWR vs. frequency have been done. Because of the band the antennas models made are to operate in, the measurement of SWR was done within the frequency range from 2 GHz to 3 GHz.

The results of the measurements for the SWR of the microstrip antennas discussed vs. frequency were presented in the Fig. 2.



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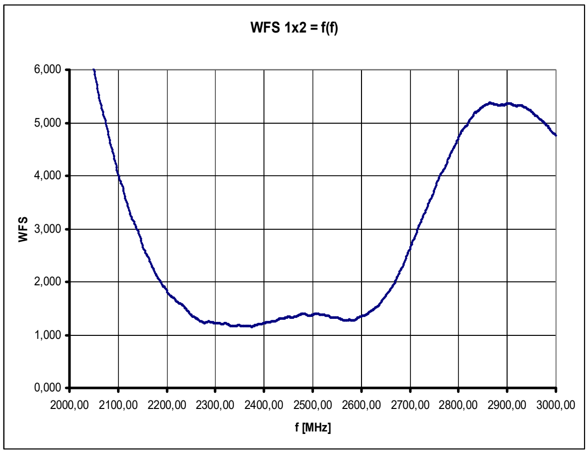

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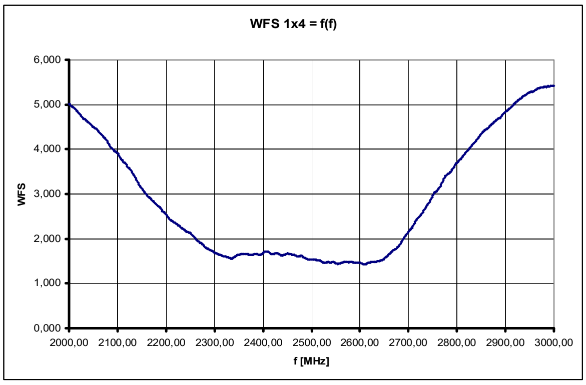


c.

Figure 2. Results of measurements SWR for microstrip antennas models designed (a. single element antenna, b. two element antenna, c. four element antenna.

3. Diagnostics of Microstrip Antennas with the Thermography Method

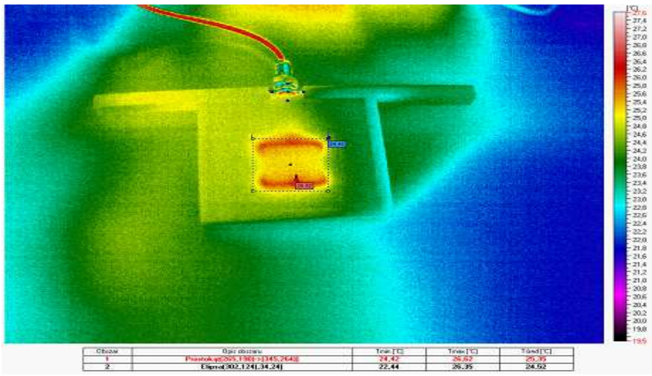
In order to verify design correctness and quality of work for the feeding systems of the aerial arrays as well as radiator of models done, except of the SWR value measurement, the results of which were presented in the previous paragraph, also the temperature distribution measurement was carried out on the surface of two models designed:

– single element antenna (Fig. 3),
– two element antenna (Fig. 4),
– four element antenna (Fig. 5),.

In order to carry out the measurements, the laboratory test stand was created consisting of:

– thermo vision camera (VIGOcam V60),
– high frequency signal generator with the regulation range from 9 kHz to 6 GHz (Rohde&Schwarz SMB 100A),
– wideband amplifier 5W (Research Amplifier).

The temperature distribution on the surface of the microstrip antenna tested in the laboratory test stand set-up was measured using the thermo vision camera. The high frequency signal generator was used as the signal source feeding the microstrip antenna. Because of low resolution of the thermo vision antenna, in order to increase eventual potentials of temperature distribution on the surface of the microstrip antenna tested the measurement signal was amplified by the power amplifier. The measurements were done in the ambient temperature 21 [°C] and in the distance of 50 cm from the surface of the microstrip antenna. The results of temperature distribution measurements received on the surface of the one, two and four element antenna are presented in the Fig. 3, 4 and 5.



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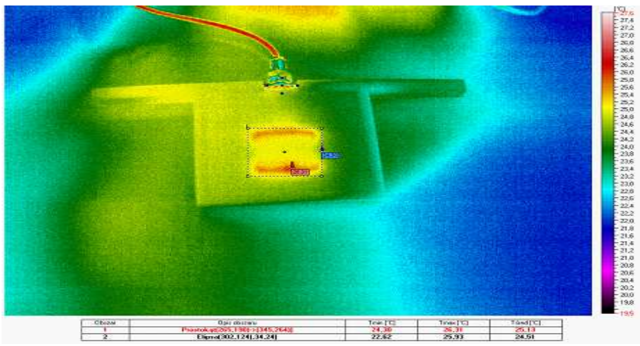
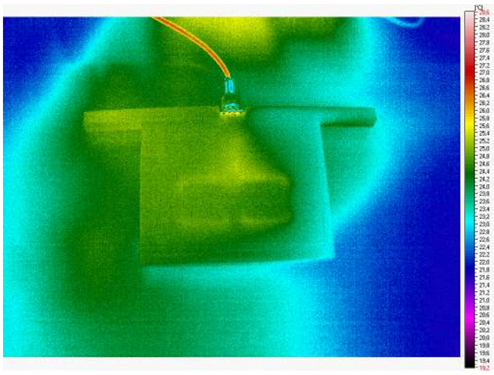


b.

Figure 3. Thermogram of the temperature distribution on the surface of a single-element microstrip antenna The antenna excited with the frequency of 2.3 GHz (a) and 2.6 GHz (b).



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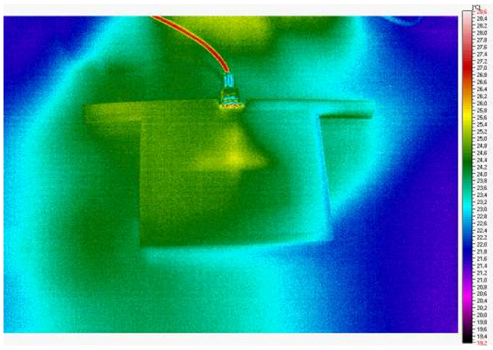
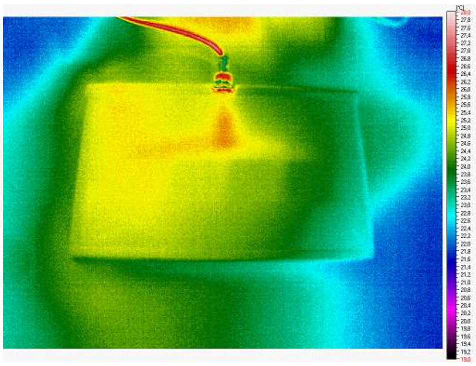


b.

Figure 4. The thermogram of the temperature distribution on the surface of two element microstrip antenna. The antenna excited with the frequency of 2.4 GHz (a) and 2.8 GHz (b).



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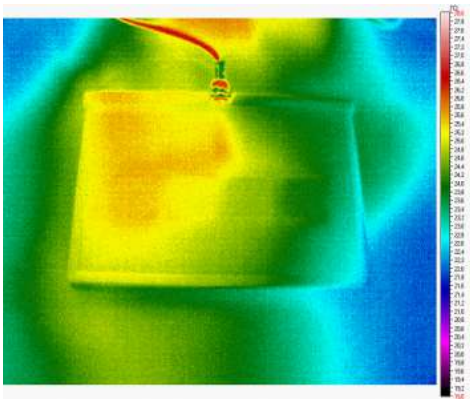

b.

Figure 5. The thermogram of the temperature distribution on the surface of four element microstrip antenna. The antenna excited with the frequency of 2.4 GHz (a) and 2.8 GHz (b).

Basing on the measurement results of the single element antenna, two areas with the biggest changes of temperature were defined using the THERM software, of the Vigo System company, for data analysis. The first area shaped as the rectangle was located in the radiator place. The second area shaped as the ellipse was located at the input terminals of the antenna. The information on minimal, maximal as well as average temperatures was selected from the data collected for these two areas.

Analysis of thermograms achieved confirms consistence of the transmission line model [3] describing operation of the microstrip antenna with the achieved measurement results of the temperature distribution. This model presents a microstrip antenna as two narrow radiating surfaces separated by a transmission line of length L, which has a low impedance equal to Z_c. Because of finite dimensions of the radiator (length and width), waves propagate themselves mainly at its edges.

The thermograms presented allow unequivocally to state that the feeding system designed can be potentially the place of high power losses, and in the future it can be a potential place of the antenna damage. Therefore, taper transformers should be used that provide smooth impedance transformation, and by this better matching.

4. Conclusions

Analysing the results of tests carried out it can be stated that there is a dependence between the temperature distribution of the microstrip antenna and the SWR. This dependence can be observed by comparing the diagram of SWR with the temperature of the radiator as the function of frequencies. The minimal temperature for the single-element antenna was achieved exactly at the same places, where the SWR was the smallest one, i.e. at the frequencies of 2.3 GHz and 2.6 GHz.

In the case of antenna input terminals, the higher SWR the higher temperature of the area. The above phenomenon can be observed in situations, when the antenna has been excited by the signal of frequency out of its working band. As an effect of this the most part of the power has been reflected and a considerable part of it has been changed into heat.

The shape of the average and maximal temperature characteristic within the radiator area is the same. Changes of the maximal temperature are contained in the range of 1.6 °C, but the changes of the average temperature of the antenna are maximum 0.9 °C in the area marked. Because of this reason, the thermo vision camera used for this type of applications should have the resolution not lower than 0.1 °C. If this condition is not satisfied, the incorrect read out of changes taking place in the antenna temperature distribution could be the result of this.

Within the area of input terminals of the antenna, the maximal temperature is changing in the range of 1 °C, but the average temperature – in the range of 0.5 °C. In this case, shapes of the characteristic differ each other and the maximal temperature only demonstrates considerable correlation with the SWR measurement results. It can be supposed that the design of the antenna with the electromagnetic coupling is the reason of this phenomenon. The terminals are not fully visible, as the radiator, for the thermo vision camera, and because of this the measurement is less accurate. Also, the terminals themselves have much lower surface than the radiator, therefore, the measurement is averaged of lower number of the measurement points (the resolution of the camera image is 640x480 pixels).

Because of their geometrical dimensions, antennas consisted of two and four elements are not able to become heated themselves to the same degree as the single-element antenna. It is resulted from too small power delivered to the input terminals of such antennas. The input signal power for antennas of these dimensions should be at least twice higher.

As it is seen at the thermograms, the ambient environment of the antenna tested is not of the uniform temperature. The reason of this phenomenon is the influence of external factors, as reflections from the measurement table of the radiations coming from illuminations and other elements interfering the thermo vision measurement. This problem can be minimised by placing the antenna on the substrate of small reflection coefficient for thermal radiation.

The antennas were tested in the ambient temperature of 21[°C]. It can be supposed that if the measurements were done in the lower ambient temperature, the differences between becoming heated components of the microstrip antenna structure would be much more visible.

Basing on the tests carried out it can be stated unequivocally that the temperature distribution of microstrip antennas allow to make the diagnostic of their parameters. Because of wide applications of microstrip antennas in cellular telephony networks and their mass production, the remote diagnostics of their parameters can be used for more fast development of this technology.

7. References

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