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RESEARCH OF GARMENTS MATERIAL REFLECTIVITY WITHIN THE RANGE OF MICROWAVE FREQUENCY (SHF)

Much attention has been paid to the behavior of the different materials in the electromagnetic fields of different intensity. The paper presents the further development of researches of the material reflectivity within the super-high-frequency band (SHF) with the use of the highly sensitive radiometric system (RS) and resonance properties of leather materials for making garments.

Authors have developed the structural schema of RS researched the peculiarities of its work.

Keywords: *radiometric system (RS), super-high-frequency (SHF), factor of reflection, frequency band, electromagnetic field, density of capacity.*

Introduction. Task setting

Research of garments material reflectivity within the wide band of SHF range is the important task for the scientific and technical researches in external electromagnetic field [1]. The devices, generating and radiating the monochromatic electromagnetic emission during the smooth frequency variation within the range of 40 - 80 GHz with the controlled density output, or the noise radiation with the controlled spectral output density are used to research the garments material reflectivity within the wide band of SHF range [2].

The existing research methods, however, suffer from significant errors and do not fit the modern requirements of the technical and scientific researches.

Basic part

The paper presents the new radiometric system, which helps overcome the above drawbacks. This radiometric system combines the generating part of the device with the receiving- radiating part [3].

The fig. presents the schema of the device for the research of the reflectivity of garments material within the band of SHF range.

Monochromatic oscillation of the SHF-generator 1 frequency f_1 through the power divider 2, the first variable attenuator 3 and the first directed coupler 4 enter the amplitude modulator 6, the controlling input of which is influenced by the modulating frequency voltage F_1 from the low-frequency oscillator 16 through the scaler 17. The amplitude modulator 6 is made on *p-i-n* diodes and operates on the SHF signal reflecting principles from the closed amplitude modulator, that is , with the 100% factor of the amplitude modulation percentage. When the amplitude modulator 6 is opened, the monochromatic SHF-signal through the valve 7 and the second directed coupler 8 enters the receiving-emitting antenna 9 and is emitted on the selected section 21 of the garments material. The required level of the SHF-radiation intensively is set with the help of the first variable attenuator. Part of the radiated SHF signal energy reflects form the garment material and enters the receiving-emitting antenna 9. The accepted signal through the arm of the second directed coupler8 and the arm of the double waveguiding branch box 10 enters the input of the balanced mixer 11.

Amplitude modulator 6 is switched by the voltage frequency F_2 from the frequency divider 17.In the following half-cycle of controlling voltage ($\frac{1}{2}F_2$) the amplitude modulator 6 shall be closed and the SHF generator signal 1 is reflected from the closed amplitude modulator 6. The reflected signal through the arm of the first directed coupler 4 enters the second variable attenuator 5. The weakened signal on the output of the second variable attenuator 5 through the second arm of the double waveguiding branch box 10 also enters the input of the balanced mixer 11. The balancing of the reflected signals with the part of the fading one occurs dew to the second variable attenuator 5.

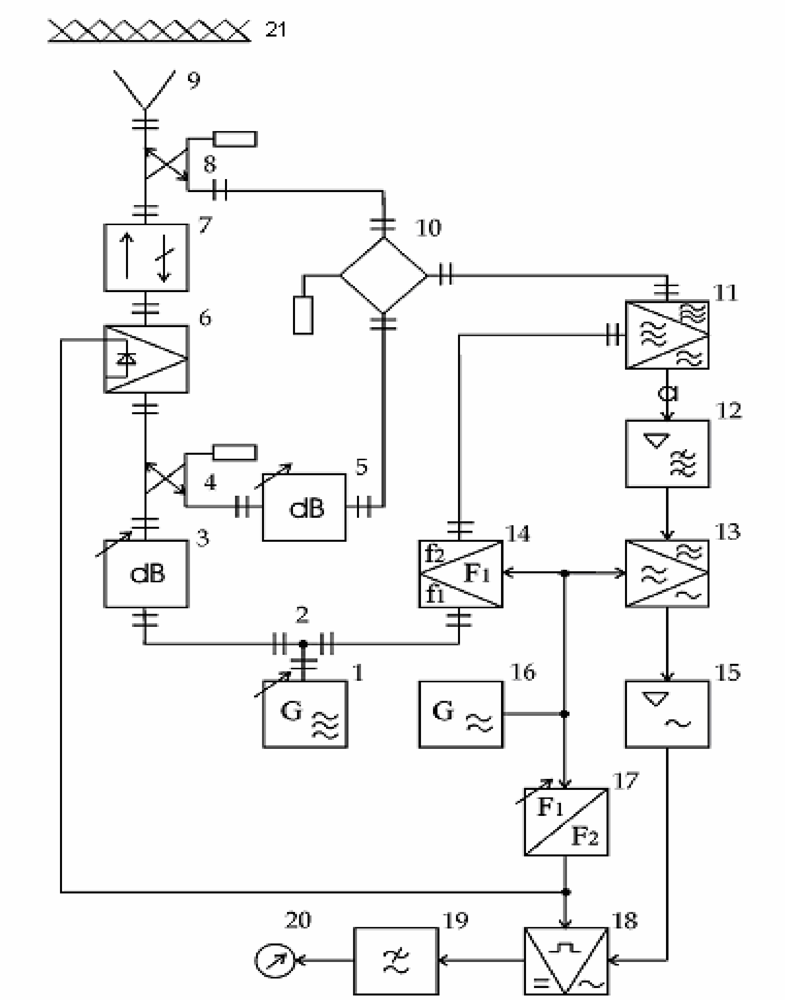

Fig. The schema of the reflectivity device for the research of the reflectivity of garments material within the band of SHF range

During the periodical operation of the amplitude modulator 6 (opened – closed), the input of the balanced mixer 11 is by turns influenced by the packages of the reflected SHF signals with the low frequency repetition rate F_2, which is set by the 17.

The uninterrupted, frequency biased by the block 14 signal from the SHF generator 1 enters the second input of the balanced mixer 11. The schema of the quadrature modulator with the recapitulated balance-modulated signals or the phase changer in the dynamic conditions may be used as the biased block 14.

In such a way the SHF signal with the frequency biased $f_2 = f_1 - F_1$ during the frequency f_1 changing of the SHF signal in the wide frequewncy range is formed on the output of the SHF biased block 14. The mixing (multiplication) of the uninterrupted, biased on the frequency SHF signal, with the packages of the reflected SHF signals occurs in the balanced mixer 11.

The radioimpulse of the different $(f_1 - f_2)$ frequency with the amplitude:

$$U_{m1} = |T_2||T_3||T_6||T_7||T_9|^2|T_8||T_{10}||\Gamma_0|S_{11}|T_{14}||E_1|^2, \quad (1)$$

Is formed on the output of the balanced mixer 11 in the first half-cycle $(\frac{1}{2}F_2)$ of the low-frequency modulating signal, where $|T_2|$ – module of the power divider transferring formation factor 2; $|T_3|$ –

module of the first variable attenuator transferring factor 3; $|T_6|$ – module of the amplitude modulator transferring factor 6; $|T_7|$ – module of the valve transferring factor 7; $|T_9|$ – module of the receiving-emitting antenna 9 transferring factor; $|T_8|$ – module of the second directed coupler transferring factor 8; $|T_{10}|$– module of the double waveguide branch box transferring factor 10; $|\Gamma_0|$ – module of the garments material reflecting factor; S_{11} – balanced mixer conversion steepness 11; $|T_{14}|$ – module of the block 14 SHF bias transferring factor; $|E_1|$ – module of the field intensity complex amplitude in the SHF generator output 1.

In the second halfcycle ($\frac{1}{2}F_2$) low-frequency modulating signal, when the amplitude modulator 6 is closed, the radioimpulse amplitude of the intercarrier frequency in the output of the balance mixer 11 accepts the meaning:

$$U_{m2} = |T_2||T_3||T_4||T_5||T_{10}|S_{11}|T_{14}||E_1|^2 , \quad (2)$$

where $|T_4|$ – module of the first directed coupler transferring factor 4; $|T_5|$ – module of the second variable attenuator 5 transferring factor.

The voltage of intercarrier frequency f_1–f_2=F_1 is singled out and amplified by the selective low-frequency amplifier 12. This voltage shall be rectified by the first synchronous detector 13, directly regulated by the low-frequency generator voltage 16. The temporal sequence of videoimpulses with the amplitudes (3) and (4) is formed on the output of the first synchronous detector 13 from the radioimpulses with the amplituders (1) and (2):

$$U_{m3} = S_{13}K_{12}U_{m1} , \quad (3)$$

$$U_{m4} = S_{13}K_{12}U_{m2} , \quad (4)$$

where K_{12} – selective low-frequency amplifier amplifying factor 12; S_{13} – speed of the first synchronous detector 13.

From the sequence of the videoimpulces frequency passage F_2 with the amplitudes U_{m3} and U_{m4} amplifying 15 alternating voltage, there is the selection and amplifying of the voltage of the bypass of this succession:

$$U5(t)= K15 \text{ sign} \sin(2\pi F2t - \Phi) = K15 \frac{U_{m5}}{2} \text{ sign} \sin(2\pi F2t - \Phi), \quad (5)$$

where K_{15} – alternating voltage 15 amplifying factor; Φ – bypass phase; sign sin ($2\pi F_2 t$–Φ) – rectilinear bypass of the videoimpulses succession.

The amplified alternating voltage shall be rectified by the second synchronous detector 18, controlled by the initial voltage of the scaler 17. The rectified voltage from the output of the second synchronous detector 18 is smoothed by the low-pass filter 19 and considering the expressions (1) ... (4) looks like:

$$U_6 = K_{19}S_{18}U_{m5} = \frac{|T_2|}{2}|T_3||T_{10}||T_{14}|S_{11}S_{13}K_{12}K_{15}|E_1|^2 K_{19}S_{18} \times$$
$$\times \left(|T_4||T_5| - |T_6||T_7||T_9|^2|\Gamma_0|\right), \quad (6)$$

where S_{18} – speed of the second synchronous detector 18; K_{19} – transferring factor of the low-pass filter 19.

The direct voltage U_6, which answers the frequency f_1 of the SHF generator 1, is measured by the voltmeter 20. The expression (6) shows that the initial voltage of the low frequency filter is proportional to the difference between the radiated and the reflected energy. That is why the calculating voltage is proportional to the devoured energy.

Regulation of the frequency f_1 of the SHF generator 1 is executed in the following way. First, the frequency f_1 of the SHF generator 1 is set on the low boundary of the operating frequency range (37 – 40 GHz). Frequency F_1 of the low frequency generator 16 shall be selected as the fixed (1 – 2 kHz), which ensures the constant bias of the regulated frequency of the SHF generator 1. The factor of the distribution of the scaler 17 shall be regulated in a way to change the modulation frequency F_2 within 1 up to 100 GHz.

The zero value of the voltmeter 20 is achieved by regulating the transferring factor of the second variable attenuator 5 regulation. When $U_6 = 0$ the equality is set:

$$|T_4||T_5^{'}| = |T_6||T_7||T_9|^2|\Gamma_0|, \tag{7}$$

where $|T_5^{'}|$ – module of the second variable attenuator 5 transferring factor, which corresponds to the zero value of the voltmeter voltage 20.

Then, the radiation frequency should be smoothly increased, observing the voltmeter meterage 20. When the SHF radiation coincides with the resonance frequency of the garments material absorption, the material reflecting factor Γ_0 decreases sharply. In the regime of resonance absorption of the SHF energy, the reflecting factor approaches the zero, ($\Gamma_0 \approx 0$), and the voltmeter indications 20 considering the equation (7) increase to the following:

$$U_7 = \frac{|T_2|}{2}|T_3||T_4||T_5^{'}||T_{10}||T_{14}|S_{11}S_{13}S_{18}K_{12}K_{15}K_{19}|E_1|^2 . \tag{8}$$

With the further increasing of the frequency of the microwave generator 1 the reading of the voltmeter 20 decrease practically to zero, which means the leaving of the resonance zone. Increasing the microwave generator frequency 1 to the upper limit allows to determine the resonance frequencies of absorption.

Conclusion

The previous experiments showed that within the frequency range of 37 ... 78 GHz, during the leather materials researches the resonance absorption within some frequencies is observed along with the monotonous change of absorption factorпри. The density of the radiating capacity changed within the range of 0,001 up to 0,01 microwatt / sм ^{2}.

Consequently, the suggested high-sensitive radiometric system allows to determine with higher accuracy some characteristics of the leather materials used for producing garments.

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