TIME DOMAIN MEASUREMENT OF REFLECTION COEFFICIENT OF ABSORBERS

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Time Domain measurement of reflection coefficient of absorbers in near and in far field in the 8 to 18 GHz frequency band is considered. Calibrations are described allowing to increase accuracy of measurement.

Measurement system is used to measure a reflection coefficient of absorbers in the 8 to 18 GHz frequency band. The principle of the act of system is based on forming short picosecond pulse, transmitting it by transmitting antenna, receiving reflected from object signal by receiving antenna, and transforming by sampling head of sampling oscilloscope.

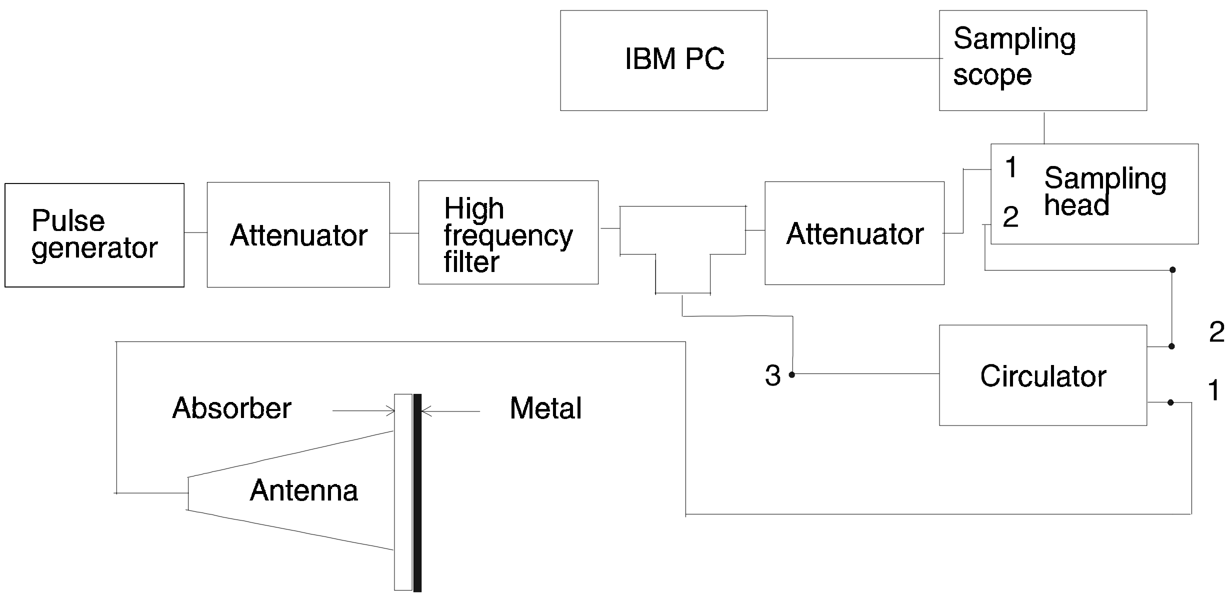

Fig. 1

The scheme of measurement in near field is shown in Fig. 1. In this case object under test is about with antenna and is used only one antenna to transmit and receive electromagnetic pulse. Pulse generator forms short picosecond pulse. High

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frequency filter is used to cut off low frequency of signal that is multiply reflected between circulator and coaxial-waveguide adapter that allows to eliminate a large background. Circulator in direction from generator to sampling head (3-2) decreases amplitude of signal by 15 dB in 8-18 GHz band. Pulse in direction 3-1 is applied to pyramidal horn antenna with aperture 10x15 cm for 8-12.4 GHz band and 8x12 cm for 12-18 GHz band. The signal reflected from object under test is transformed by sampling oscilloscope using one of it's channels. Other channel of oscilloscope is used for phase stabilization to eliminate a signal's drift during long time measurement for great amount of absorbers. The sampling oscilloscope SD 018 produced by Zondas Ltd. was used for these measurements. That is a computer-based fully programmable two channels oscilloscope with frequency band to 18 GHz. A rise time 15 ps and small noise factor (r.m.s. is equal 1.7 mV) allows to use it in wide range time and frequency domains measurements. The measurement procedure is the following. Place the metallic plate against the horn to obtain a calibration signal $f_m^{\prime}(t)$, which is a sum of signal reflected from metallic plate $f_m(t)$, and back part of incident signal $f_0(t)$. Then is entered a signal when a horn aperture is free. In this case the resulting signal $f_0^{\prime}(t)$ is a sum of signal $f_0(t)$ and signal reflected from horn aperture $f_a(t)$. Place the object under test against the horn to obtain a signal $f^{\prime}(t)$ which is a sum of signal reflected from object under test $f(t)$ and signal $f_0(t)$. For reflection coefficient is obtained the next formula:

$$R(w) = \frac{F^{\prime}(w) - F_0(w)}{F_m^{\prime}(w) - F_0(w)}\ , \qquad (1)$$

where $F_i(w)$ is Fourier transform of $f_i(t)$. Taking in account that $f_a(t)$ is small we can obtain the next formula:

$$R(w) = R^{\prime}(w) + A(w), \qquad (2)$$

where $R^{\prime}(w) = \frac{F^{\prime}(w) - F_0^{\prime}(w)}{F_m^{\prime}(w) - F_0^{\prime}(w)}$, $A(w) = \frac{F_a(w)}{F_m^{\prime}(w) - F_0^{\prime}(w)}$.

A first member of the sum in (2) is larger than second.

To calculate reflection coefficient from (2) we have to determine the signal $f_a(t)$. This signal is calculated by measurement of reflected signal in case when an additional regular waveguide is used between antenna and absorber with cross section equal to aperture of antenna. The signal $f_a(t)$ is calculated from formula:

$$f_a(t) = f_0^{\prime}(t) - f_0^{\prime\prime}(t)\ , \qquad (3)$$

where $f_0^{\prime\prime}(t)$ is a signal measured in the same time window for antenna with free aperture when an additional waveguide is used that allows to shift a signal reflected from antenna's aperture outside the selected time window. The mean of $A(w)$ in (2) is independent of object under test and characterises measurement system. It may be stored in computer memory as correction.

Using proposed calibrations we can measure the reflection coefficient of absorbers with a value less than that of reflection coefficient from antenna's aperture.

This measurement in near field is used to investigate small areas of absorbers.

In measurement in far field two different antennas for transmitting and receiving of electromagnetic wave are used. In this case the object under test is placed at the distance Z, corresponding to far field, i.e. $Z = \frac{2D^2}{\lambda}$, where D is the largest size of cross section of antenna's aperture, λ - wave length. Reflected from object signal is received by receiving antenna and is transformed by sampling oscilloscope. Three signals are entered in the same time window: a signal $f'_m(t)$ reflected by metal side of object under test, a signal $f'(t)$ reflected by absorber side and a signal $f_0(t)$ without reflectors. The reflection coefficient is calculated from formula:

$$R(w) = \frac{F(w)}{F_m(w)}, \qquad (4)$$

where $F(w)$ is Fourier spectrum of $f(t) = f'(t) - f_0(t)$ and $F_m(w)$ is Fourier spectrum of $f_m(t) = f'_m(t) - f_0(t)$. In this case is assumed that cross section of metallic reflector and absorber is the same.

Using measurement in far field we can determine an average value of reflection coefficient over absorber's surface. In this case it is easy to choose a time window due to missing of multiple reflections that allows to investigate objects which have resonance in frequency dependence of reflection coefficient.

Using measurement in near field it is possible to define a reflection coefficient less than a reflection coefficient from antenna's aperture in contrast to measurement in Frequency Domain [1].

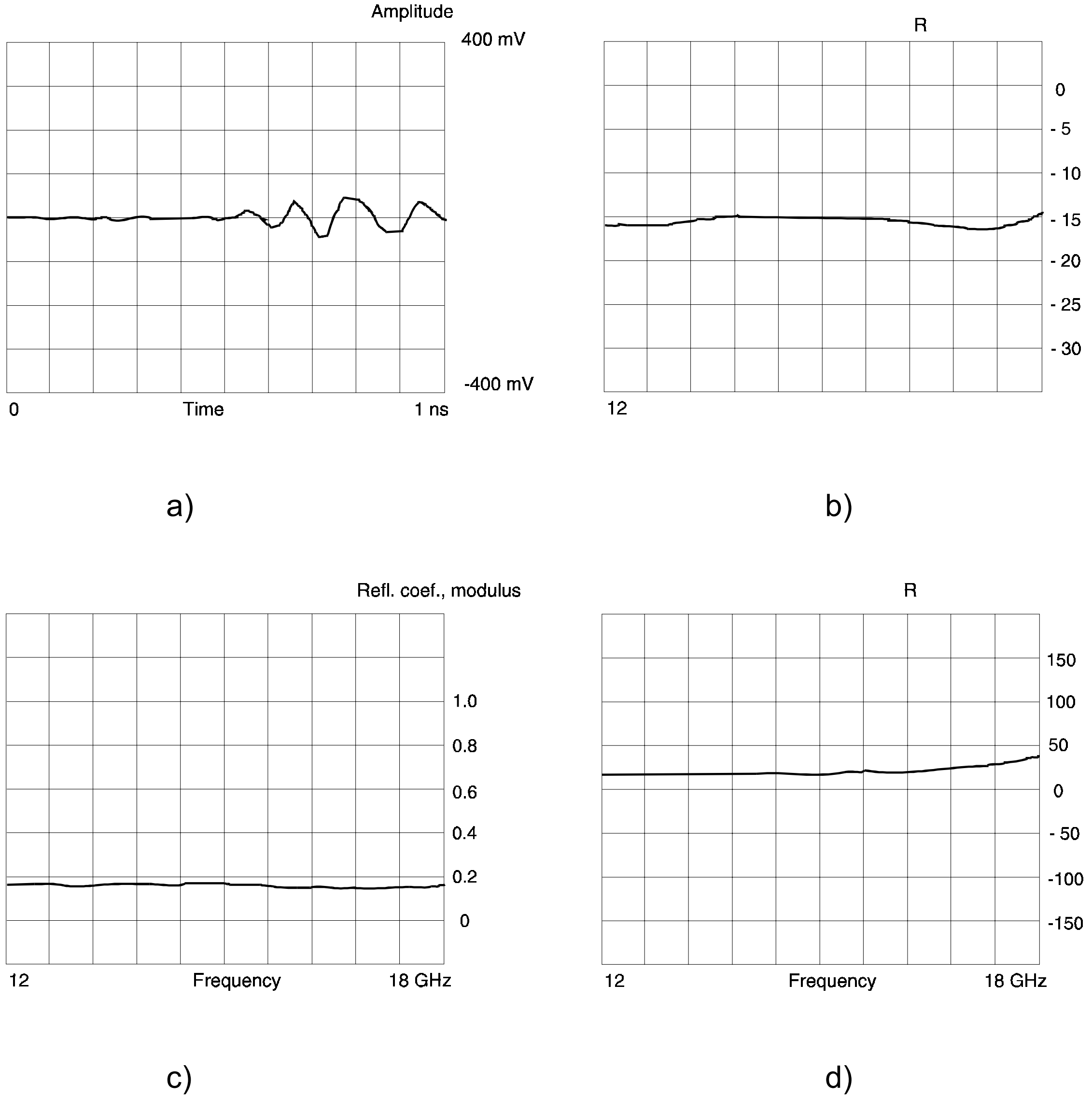

Fig. 2.

A measurement in near and in far field were used to investigate absorbers with small meaning of reflection coefficient. At Fig. 2 some results are presented. At Fig. 2 a) is shown a reflected from absorber signal, at Fig. 2 b,c) - a modulus and at Fig. 2 d) - a phase of reflection coefficient. The results of measurement in near and in far field were similar an for reflection coefficient about - 20 dB a difference was less than 0.5 dB.

References

1. D.E.Baker and C.A. van der Neut. Reflection Measurements of Microwave Absorbers./ /Microwave Journal. - December 1988. - pp. 95-104.