The Engineering Implement of Antenna Time-domain Near-field Measurement System

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Abstract

At present, a complete measurement system has been built up successfully by our laboratory, besides its engineering implement has been accomplished also. We can show an antenna's radiation field in a form of 3D animation dynamically with this measurement system, which demonstrates the time-domain near-field measurement theory and the time-domain near-field measurement system are practical. The present paper will introduce the basic principles, the components of the system and the essential techniques. The screenshots of the dynamic 3D animation will be shown in the part of conclusion at last.

1. Introduction

The antenna time-domain near-field measurement technique is a new technique, which can obtain antenna's time-domain field and broad-band radiation characteristics accurately. Since the inception of antenna engineering, the antenna measurement is one of the important subjects of researcher's concern. In the process of solving problems of antenna technology, the researches of antenna measurement and antenna theory have the same importance. From traditional far-field antenna measurements to the more mature frequency-domain near-field measurement until the antenna time-domain near-field measurement, the developments of the antenna measurement experience three main stages. Until now, near-field measurement is becoming mature whose basic method is: using a short-pulse of broadband to feed the AUT (antenna under test) and with a probe which adapts for the time-domain measurement to scan and collect sampling data on the plane away 3~10 wavelength from the antenna aperture. After recording the time-domain waveform, applying the theorem of sampling and near-field to far-field transforms algorithm to yield the far-field pattern of time-domain and frequency-domain.

Our laboratory has studied the essential techniques of the system since 1996. In the aspects of the overall design of the system, time-domain planar near-field sampling theory, error analysis and correction theory, control of test equipments and data processing and analysis software, the process of sampling data and transformation of near-field to far-field, we have made a substantial progress. The final results prove the research of the time-domain measurement theory is correct and the engineering implement of this system is practical.

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2. The components of measurement system

The antenna time-domain near-field measurement system has three main components: (1) T/R device: it is used to motivate the time-domain signal resource of AUT and time-domain signal receiver. (2) Probe: it should be the UWB antenna which has following characteristics: weak directional, pure polarization, small near-field disturbance. (3) The sampling frame and proper scanning method for the time-domain measurement. (4) A microwave shielding chamber which can provide a purer electromagnetic environment. In the details of the components: 1) Broadband narrow pulse generator. It is used to transmit the periodical time-domain narrow pulse to incentive AUT. The most important advantage of time-domain measurement is the AUT's radiation characteristics in the broadband can be obtained through one process of scanning and sampling. The narrower the excitation pulse is, the wider the frequency band of time-domain response signal of AUT. 2) Digital sampling oscilloscope: Although the AUT's time-domain response signal has the long tail phenomenon, it is still a periodical time-domain narrow signal under the excitation of narrow pulse in a stable periodic. It is unable to satisfy the Nyquist sampling theorem, so this kind of signal must be sampled cycle with high-performance digital sampling oscilloscope and the data was recorded and stored soon after. 3) Stable and accurate motion control card & plane sweep sampling frame: The basic theory of antenna time-domain near-field measurement is to obtain the near-field time-domain response pattern of inciting the AUT with narrow pulse and compute the far-field pattern of AUT with time-frequency transform and near-field to far-field transform. In the process of sampling, a small position error will impact the final result greatly, so the standard of sampling frame must be very high. 4) Measuring probe: Due to the time-domain measurement system is needed to record the near-field data of the broadband in one scanning process, the measuring probe not only has characteristics of weak directional, pure polarization and small near-field disturbance, but also its frequency response can cover output signal frequency of signal resource.

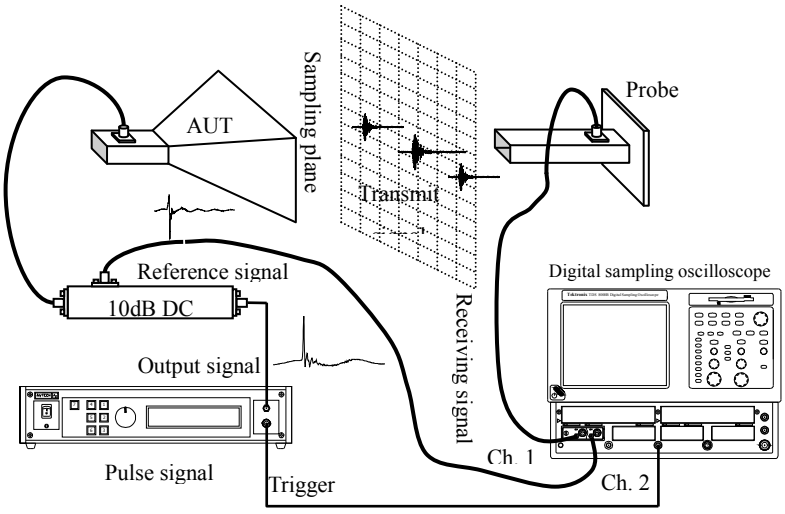

Fig. 1 Antenna time-domain near-field measurement system connection diagram

3. The time-domain error analysis and correction

The 21 terms of frequency-domain error analysis are mature whose analytical expressions had been given by researchers. However, the time-domain measurement system not only has the above errors but also has its own unique sources of error. The time-domain sampling length error is the most essential one which is the specific

parameter of time-domain measurement. Both of the shorter and longer time length adopted in measurement will cause serious reflection to the final results. We have conducted in-depth research on this subject, many results of this research have been applied to the software of data processing and analysis which ensure the final measurement results are accurate and the system is practical.

4. Antenna's test results

We began with an L-band standard gain horn, the distance between sampling plane and antenna aperture plane is three wavelengths (about 900 mm), the sampling length of H plane is 1710mm, the sampling step interval is 90mm, the timegate we adopted is 5.4ns.

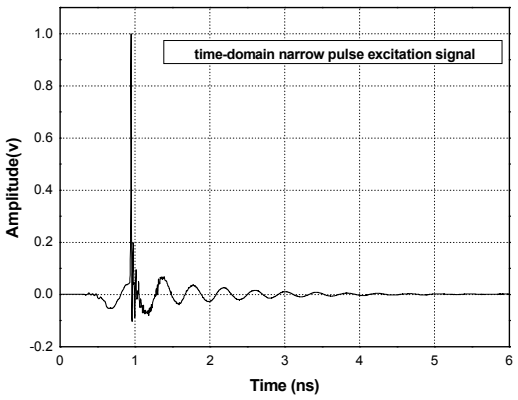

Fig. 2 time-domain narrow pulse transmit signal

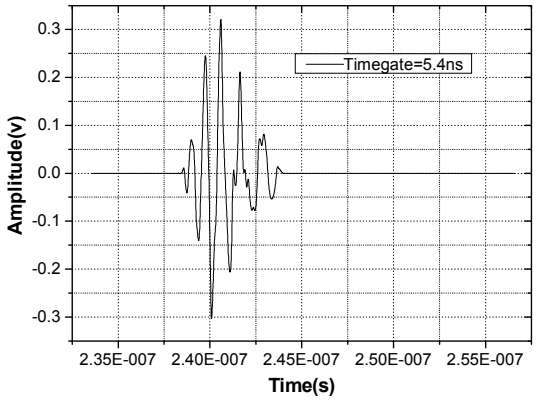

Fig. 3 The time-domain response signal of L-band standard gain horn Timegate is 5.4ns

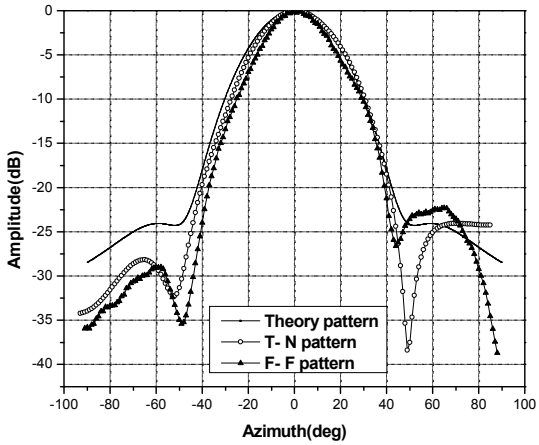

Fig. 4 H plane measurement results of S band standard gain horn，T- N pattern stands for time-domain near-field measurement pattern；F- F pattern stands for frequency-domain far-field measurement pattern

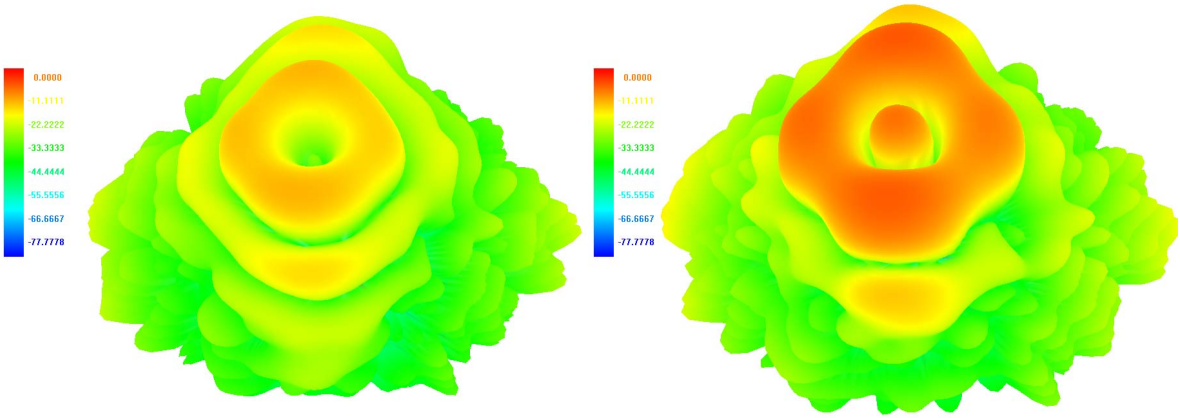

Fig. 5 The screenshots of the dynamic 3D animation of antenna time-domain far-field measurements belong to S-band standard gain horn

5. Conclusion

From above figures and the comparisons of theory pattern and measurement patterns, we can prove that the theories of antenna time-domain near-field measurement are correct; the test results measured by this system are stable; the engineering implement of this system is successful which can meet the requirements of practical tests. We master the key techniques of every component of this system and a large number of first-hand data which will be helpful to the future work of next stage.

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